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Soil Resource Management Handbook for the Eugene District

By

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This handbook was prepared to serve as a guideline for the management of lands administered by the Eugene, Oregon District of the Bureau of Land Management.

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Contents

I. Introduction

II. Soil Behavior and Mitigating Recommendations by Soil Series

III. Summation of Soil Behavior and Mitigating Recommendations

IV. Additional Soil Characteristics and Ratings:

  A. Soil Genetic and Physical Properties

  B. Productivity for Douglas-fir

  C. Regeneration Limitations for Douglas-fir

  D. Soil Compaction Hazard

  E. Mass Movement Hazard

  F. Engineering Interpretations

VI. Appendix

  A. Index to Soil Series by Mapping Unit Symbol

  B. Acreage and Proportionate Extent of Mapping Units on Eugene District

  C. Genetic Key to the Soil Series

  D. Soil Classification

  E. Table 1. Genetic Key to the Soil Series

  F. Table 2. Relationship Between Permeability, Precipitation, and Runoff

  G. Table 3. Productivity Potential of the Most Common Soils by Resource Area

  H. Table 4. Regeneration, Burning, Compaction Hazard Ratings

  I. Table 5. Engineering Properties and Limitation Ratings

  J. Table 6. Erosion Resistance of Various Subgrade Soils (Unified Classification)

  K. Table 7. Thickness Design by AASHO Classification

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L. Table 8. Engineering Properties of Soils by AASHO Classification

M. Table 9. ______________________________
____

N. Table 10. ______________________________
____

O. Table 11. ______________________________
____

P. ______________________________
____

I. Introduction

This handbook contains interpretations of technical data and field observations useful as a basis for making land management decisions. It was made primarily to provide information about the behavior of the dominant soil series of the Eugene District under various management precriptions or practices. This handbook consists of a narrative description of the expected response or behavior of each soil series and interpretive tables for their various potentials and limitations. The data presented here should assist foresters in timber sale layout and the selection of harvesting and reforestation practices. It should help engineers in selecting sites for stable roads and in identifying the technology necessary for the avoidance of mass wasting. It is appropriate and desirable to place the soil behavior and mitigating recommendations for the applicable soil series directly in the Environmental Analysis Records (EAR's).

It is not feasible at this point in time to provide a soil inventory map of sufficient detail to serve as the sole means for identification of specific soil series occurring on a given site and for the identification of their location within a project site or sale. However, the existing soil maps prepared by the Bureau and by the Soil Conservation Service are quite adequate as the first approximation of the soil series involved within a given sale or project area. It is imperative that foresters, engineers, and other resource specialists be capable of differentiating between the common or dominant soil series on a given site, utilizing basic soil physical characteristics. Narrative descriptions, tables, and keys based on or describing basic soil physical characteristics are included to assist in the identification of major soil types. Training opportunities will be available as often as is feasible and in conjunction with this handbook should help to minimize any unnecessarily esoteric aspects of this knowledge.

The soil resource is renewable only over a very long period of time and is the most critical resource. Ideally, proper management of the resource base has the goal of maximizing economic returns without causing an adverse impact on long-term productivity or on environmental quality. This handbook is intended to serve as a guideline toward the achievement of that goal.

The soil inventory maps presently available were prepared by the Soil Conservation Service, USDA. The delineations on these maps are called mapping units and consist of a combination of soil series and slope classes. Each mapping unit contains about the same proportions and pattern of soil series, phases of soil series and slope classes. A soil series is a grouping of soils having similar chemical and physical properties resulting in similar responses to management. A mapping unit may contain up to 25 percent dissimilar or contrasting soil series as inclusions and a much higher percentage of its composition as similar or "like" soil series.

Mapping unit composition or structure is not always sufficiently relevant to a specific project or site such as a specific timber sale or road. Shallow soils such as Umpcoos and Jason are often treated as inclusions in mapping units dominated by moderately deep soils or rockland, yet these soils have highly critical implications to timber harvesting, reforestation efforts and to road construction. It is essential that the soil maps and mapping unit descriptions be used only as general planning aids and in conjunction with "on-site" inspections for a specific project. Although the soil maps may often be too general, the soil behavior sections are quite specific for each soil series. These soil behavior sections may be applied with confidence and reliability through on-site inspections. This handbook in conjunction with District training opportunities should allow the use or application of soil behavior data on many areas by foresters and engineers at initial activity planning stages, indepently of the District Soil Scientist.

Appendix A, correlates the mapping unit symbols used by the Soil Conservation Service to the appropriate soil series. The actual composition and occurrence of the soil series on a specific site must be determined and verified by field inspections within the context or objectives of a specific activity. The soil series identified by the mapping unit symbol will serve primarily as indicators of the most common occurrences for the area. It will help considerably by channeling one's perspective to a limited number or grouping of soil series commonly associated together. The field inspections would serve to highly intensive the relevance of this data to a specific project or site by intensively identifying the occurrence of shallow or rocky soils, rock outcrops, critical headwalls, high water tables or subsurface flows, and other critical properties.

It is important to note the repetitive nature of many of the soil behavior predictions and mitigating recommendations and the underlying pattern of repetition from one soil series to another. Part III of this handbook outlines these recommendations according to the actual determining criteria. Foresters and engineers need learn only those criteria or characteristics that significantly impact soil behavior for their specific area of concern. This substantially narrows the range of terminology and characteristics necessary for field differentiation between soil types.

The soil behavior narratives and mitigating measures were written with the intent that they be used directly in Supplemental Environmental Analysis Records and are required in Step 2 of the URA (OSO Manual Supplement No. 1605). When they are incorporated into initial stages of activity planning, they should serve to substantially reduce conflicts at later stages of activity planning and implementation.

This handbook should be viewed as dynamic and should be continually updated by input from area staffs and should be utilized in the training of new employees to District problems and needs. It should

prove to be an increasingly useful reference for all resource specialists providing that it remains subject to continual additions and revisions.

II. Soil Behavior and Mitigating Recommendations by Soil Series

Apt Series (50)

The Apt series consists of deep, well-drained, brown, clayey soils developed in sandstone colluvium in areas receiving from 60 to 90 inches of precipitation. These soils occur on gently sloping to steep slump benches and sideslopes in the Coast Range at elevations of 500 to 1,500 feet.

Soil Behavoir and Recommendations:

The Apt soils are used for timber production, water supply purposes, recreation, and by wildlife. Apt soils support stands of Douglas-fir with Western redcedar, Western hemlock, bigleaf maple and an understory of vine maple, salal, oxalis, and sword fern. Site index ranges from 165 to 186 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are among the most highly productive forest soils in Western Oregon.

Clearcutting is the recommended harvesting practice for Apt soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Apt soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Apt soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Apt soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.
4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.
5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.
6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cably system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.
2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also

reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Apt soils form over tuffs and breccias and contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. It is recommended that all roads be rocked. Extra rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Apt soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered.

Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Apt soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

ATRING SERIES (394)

The Atring series consists of moderately deep, well drained, brown, loamy-skeletal soils formed in colluvium from sedimentary rocks in areas receiving from 30 to 50 inches of precipitation. They occur on steep and very steep slopes in the Coast Range at elevations of 800 to 2,600 feet.

Soil Behavior and Recommendations:

The Atring soils are used for timber production, water supply purposes, and by wildlife. Atring soils support stands of Douglas-fir with bigleaf maple, incense cedar, grand fir, and an understory of either the hazel-ocean spray, or the salal-Oregon grape plant communities. Average site index is 136 for northerly aspects and 120 for southerly aspects. Generally, the timber site class is III for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber-producing soils which dominate the District. The major limitations for timber production are the low moisture holding capacity and stoniness associated with these soils. These characteristics combined with the predominate occurrence of Atring soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly exposures. Soil lost by creep and ravel on steep slopes after clearcutting, vegetative competition and droughty conditions on southerly aspects contribute generally to a poor to fair reforestation success.

The upper 20 inches of Atring soils have a moderate water holding capacity. The high amount of coarse fragments, the loam or silt loam textures, and the moderate amount of organic matter blend to produce a water holding capacity that is between 2.5 and 3.5 inches. This amount of moisture is adequate for survival of Douglas-fir bare-root stock. It is not adequate for the survival of bare-root Douglas-fir in clearcuts on very steep southerly and westerly aspects. Clearcutting is not recommended on slopes in excess of 80 percent on those aspects and partial cutting should not exceed 40 percent of the stand.

Atring soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Atring soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Atring soils contain low amounts of organic matter and nitrogen. Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on Atring soils. They are somewhat

excessively drained, relatively low in clay minerals and subsequently have a low ability to absorb and retain applied chemicals, thus increasing the hazard of herbicides being translocated to ground or surface water reservoirs or streams. Herbicide usage also kills vegetation which through live residual root systems would contribute to slope stability.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Atring soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Atring soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Atring soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Bellpine Series (13)

The Bellpine series consists of moderately deep, well-drained, red, clayey soils formed from sedimentary colluvium in areas receiving from 40 to 50 inches of precipitation annually. They are found principally between the north and south forks of the Siuslaw River and along the crest of the Coast Range - Willamette Valley divide at elevations of 600 to 1,500 feet.

Soil Behavoir and Recommendations (Bellpine soils over sedimentary rock):

The Bellpine soils are used for timber production, water supply purposes, recreation, and by wildlife. Bellpine soils support stands of Douglas-fir with oak, madrone, incense-cedar, and an understory of salal, hazel, ocean spray, and Oregon grape. Site index ranges from 135 for northerly aspects and is not available for southerly aspects. The timber site class is generally III for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber-producing soils which dominate the District. Moderate soil depth and dry summers are the major limitations to timber production.

Clearcutting is the recommended harvesting practice for Bellpine soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Bellpine soils. Competing vegetation is often a problem. Dense stands of competing brush can get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Bellpine soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Bellpine soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and tkae place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris.

Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract *administrator on the site during the operations. This should minimize *compaction and A-horizon displacement.

Road construction is generally easy in these soils. Crawler tractors equipped with a blade and a ripping attachment are usually adequate for excavation. The material below the soil is usually deeply weathered or highly fractured.

Bellpine soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill

embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegeative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Bellpine soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Soil Behavior and Recommendations (Bellpine soils over tuffs and breccias):

All the above statements for Bellpine soils over sedimentary rock apply to Bellpine soils over tuffs and breccias with the following exceptions:

1. Bellpine soils over tuffs and breccias contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. Recommendations is to rock all roads.

2. Cut slopes and fill embankments have a higher incidence of failure.

3. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Blachly Series (10)

The Blachly series consists of deep, red, clayey soils formed in fine-textured colluvium from sedimentary and volcanic rocks in areas receiving from 60 to 100 inches of precipitation. They occur on ridgetops and sideslopes in the Cascade Mountains at elevations of 1,800 to 3,200 feet.

Soil Behavoir and Recommendations:

The Blachly soils are used for timber production, water supply purposes, recreation, and by wildlife. Blachly soils support stands of Douglas-fir with Western redcedar and Western hemlock. Site index ranges from 156 to 163 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are among the most productive forest soils in Western Oregon.

Clearcutting is the recommended harvesting practice for Blachly soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Blachly soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Blachly soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Blachly soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also

reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Blachly soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).
3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Blachly soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Bohannon Series (63)

The Bohannon series consists of moderately deep, well drained, gravelly or cobbly loam soils formed in colluvium from arkosic sandstone and basic igneous rocks in areas receiving from 60 to 120 inches of precipitation. They occur on gently sloping to very steep mountainous upland at elevations of 500 to 3,000 feet.

Soil Behavior and Recommendations (Bohannon soils over sedimentary rock):

The Bohannon soils are used for timber production, water supply purposes, and by wildlife. Bohannon soils support stands of Douglas-fir with Western hemlock, grand fir, bigleaf maple, red alder, Western red cedar, and an understory of vine maple, salal, red huckleberry, Oregon grape, sword fern, and braken fern. The site index is 145 and the timber site class is generally III for Douglas-fir growing on these soils. These soils are typical of the highly productive timber producing soils which dominate the District. The major limitations for timber production are the low moisture holding capacity and stoniness associated with these soils. These characteristics when combined with the occurence of Bohannon soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly exposures. Reforestation success is generally fair to good.

The upper 20 inches of Bohannon soils have a moderate water holding capacity. The moderate amount of coarse fragments, the loam texture, and the moderate amount of organic matter blend to produce a water holding capacity that is between 2.0 and 3.6 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir. Clearcutting is [redacted] recommended for these soils.

Bohannon soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan skid roads prior to logging operation. Maximize winching distances up to 100 feet and restrict roads and skid trails to less than 10 percent of the area.

2. Require felling of trees to lead to the skid trails to reduce the ground the tractor or skidder covers.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area.

Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Bohannon soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Bohannon soils contain low amounts of organic matter and nitrogen.

Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on Bohannon soils. They are somewhat excessively drained, relatively low in clay minerals and subsequently have a low ability to absorb and retain applied chemicals, thus increasing the hazard of herbicides being translocated to ground or surface water reservoirs or streams. Herbicide usage also kills vegetation which through live residual root systems would contribute to slope stability.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Bohannon soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Bohannon soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Bohannon soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Cruiser Series (19)

The Cruiser series consists of deep, red, fine-loamy soils formed in colluvium from volcanic rocks in areas receiving over 70 inches of precipitation. They occur on ridgetops and sideslopes in the cryic temperature regime of the Cascade Mountains at elevations above 2,800 feet on northerly slopes, and above 3,200 feet on southerly slopes.

Soil Behavoir and Recommendations:

The Cruiser soils are used for timber production, water supply purposes, and by wildlife. Cruiser soils support stands of Douglas-fir with Western hemlock, Pacific silver fir, Western redcedar, and an understory of rhododendron, blue and red huckleberry, beargrass, and sword fern. Site index ranges from 125 to 140 and the timber site class is generally III for Douglas-fir growing on these soils. The major limitations for timber production are the cold soil and air temperatures and subsequent short growing season associated with Cruiser soils.

Clearcutting is the recommended harvesting practice for Cruiser soils. These soils occur in cool moist environments where the growth of Douglas-fir is good.

The upper 20 inches of Cruiser soils have a high water holding capacity. The low amount of coarse fragments, the clay loam textures, and the high organic matter content all blend together to produce a water holding capacity that is between 4.0 and 5.0 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in clearcuts. The success of bare-root Douglas-fir seedlings is high. Getting these soils planted in the fall is difficult because of early deep snows. It is recommended to consider spring planting. However, the success of spring planting will depend on a number of factors such as how early the snow leaves; how much soil moisture there is during and following planting, and how hot the spring temperatures are.

Cruiser soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceeding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Waterbar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn.

Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Cruiser soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegeative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Cruiser soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Cumley Series (5)

The Cumley series consists of deep, moderately well-drained, clayey soils formed in fine textured colluvium dominantly from basic igneous rocks including tuffs and breccia in areas receiving from 55 to 75 inches of precipitation. These soils are predominantly found on gently to moderately sloping mountain footslopes at elevations of 800 to 2,000 feet.

Soil Behavoir and Recommendations:

The Cumley soils are used for timber production, water supply purposes, recreation, and by wildlife. Cumley soils support stands of Douglas-fir with Western hemlock, red alder, Western redcedar, golden chinquapin, with an understory of sword fern, salal, bracken fern and vine maple. Average site index ranges from 146 to 162 and the timber site class is generally II or III for Douglas-fir growing on these soils. These soils are typical of the highly productive timber producing soils which dominate the District.

The upper 20 inches of Cumley soils have a high water holding capacity. The low amount of coarse fragments, the silty clay loam texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 8 and 10 inches. This amount of moisture is adequate for survival of Douglas-fir in clearcuts. The success of bare-root Douglas-fir seedlings is high.

Cumley soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 to 40 percent.

Cumley soils have a seasonal high water table and are perennially too moist to permit tractor or skidders to operate without substantial compaction occurring.

1. Require a cable yarding system and at least partial suspension of logs.

2. Permit skidders or tractors only on permanent roads.

3. Gross (YUM) yard slash to landings.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree

growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All Burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures and perennially high water table of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentrations of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction is generally easy in these soils. Crawler tractors equipped with a blade and a ripping attachment are usually adequate for excavation. The material below the soil is usually deeply weathered or highly fractured.

Cumley soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these practices.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill

embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Cumley soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Digger Series (66)

The Digger series consists of moderately deep, well drained, brown, loamy-skeletal soils formed in colluvium from arkosic sandstone. They are found on steep sideslopes, narrow ridges and headwalls at elevations of 600 to 2,800 feet in areas having an annual precipitation of 50 to 80 inches.

Soil Behavior and Recommendations:

The Digger soils are used for timber production, water supply purposes, and by wildlife. Digger soils support stands of Douglas-fir with Western hemlock, grand fir, bigleaf maple, dogwood, and an understory of salal, ocean spray, bracken fern, Oregon grape, sword fern, and vine maple. The average site index is 140 and the timber site class is generally III for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber producing soils which dominate the District. The depth of bedrock and high stone content are the major limitations for timber production.

The major limitations for timber harvest are soil loss by creep and ravel on steep slopes after clearcutting, vegetative competition and droughty conditions on southern exposures. Harvest cuts other than clearcutting should be used on slopes over 80 percent because of the severe hazard for accelerated soil creep.

The upper 20 inches of Digger soils have a moderate water holding capacity. The moderate amount of coarse fragments, the loam and silt textures, and the moderate amount of organic matter blend together to produce a water holding capacity that is between 2.5 and 3.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir stock. It is not adequate for the survival of bare-root Douglas-fir on very steep direct south and west aspects. Clearcutting is not recommended on slopes in excess of 80 percent on these aspects and partial cutting should not exceed 40 percent of the stand.

Digger soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration process through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no father apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Digger soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capial through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Digger soils contain low amounts of organic matter and nitrogen. Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics

are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Digger soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Digger soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Digger soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Dixonville Series (26)

The Dixonville series consists of moderately deep, well-drained, silty clay and clay soils formed in colluvium and residuum weathered from basalt in areas receiving from 30 to 60 inches of precipitation. They are found on gently sloping to steep foothills bordering the mountainous uplands at elevations of 350 to 2,000 feet.

Soil Behavoir and Recommendations:

The Dixonville soils are used for timber production, water supply purposes, recreation, and by wildlife. Dixonville soils support stands of Douglas-fir with Oregon white oak, and an understory of bracken fern, snowberry, hazel nut, poison oak and wild rose. Site index ranges from 110 to 125 and the timber site class is generally IV for Douglas-fir growing on these soils.

Clearcutting is the recommended harvesting practice for Dixonville soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Dixonville soils. Competing vegetation is often a problem. Dense stands of competing brush can get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Dixonville soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Dixonville soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in yards preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Dixonville soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Dixonville soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Dupee Series (4)

The Dupee series consists of deep, brown, moderately well to somewhat poorly drained, silty loam to silty clay soils formed in colluvium overlying weathered sedimentary rocks in areas receiving from 40 to 60 inches of precipitation. They occur in swales and depressions on uplands at elevations of 250 to 1,200 feet.

Soil Behavoir and Recommendations:

Dupee soils are used for timber production, water supply purposes, recreation, and by wildlife. Dupee soils support stands of Oregon white oak with poison oak, rosebush, grasses and sedges. Dupee soils are not commerical timber-producing soils.

The upper 20 inches of Dupee soils have a high water holding capacity. The low amount of coarse fragments, the silt loam, silty clay loam, and silty clay textures, and the high organic matter content, all blend together to produce a water holding capacity that is between 10 and 15 inches.

Dupee soils have an aquic moisture regime and are moderately well to somewhat poorly drained. These soil moisture conditions are not adequate for the survival of Douglas-fir seedlings. Douglas-fir grows only in isolated pockets of soil having soil moisture conditions that are atypical of these sites. Reforestation efforts are likely to fail and it is subsequently recommended that Douglas-fir not be harvested on these soils.

However, if harvesting of Douglas-fir must take place then the following must be considered:

Dupee soils are high in clay content. They compact easily from tractor logging. Soil compaction will add substantially to the already critical reforestation properties of these soils. The aquic soil moisture regime of these soils precludes the mitigation of compacting by ripping. Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs.

2. Permit skidders including low ground pressure tractors only on permanent roads.

3. Gross yard slash to landings.

Moisture conditions on these soils prevent the burning of slash on site and necessitate removal to landings. Moisture conditions in combination with the high compaction hazard preclude the use of tractors or skidders in yarding or slash removal operations.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on these soils. the topographic

position and soil moisture conditions gives Dupee soils an intrinsically high hazard with respect to the translocation of herbicides to ground or surface water.

Road construction is substantialy complicated by the aquic moisture regime and the poor to somewhat poorly drained properties associated with Dupee soils. Successful road construction and maintenance requires measures to mitigate the impacts from these properties. Recommendations are:

1. Improve surface drainage, where feasible, by connecting sag ponds and depressions to the nearest stream channel with ditches.

2. Lower the ground water level by means of perforated pipe that is augered into the slope at a slight upward angle. These drains are usually installed in road cutbanks to stabilize areas above an existing road or below roads to stabilize fills.

3. Use rock riprap, or rock buttresses, to provide support for road cuts or fills. Heavy rock riprap replaces the stabilizing weight that is removed by excavation during road construction and it is porous and will allow groundwater to drain out of the slump material.

4. Install interceptor drains to collect the groundwater that is moving laterally downslope, under the road, and saturating the road fill.

5. Compact fills when crossing small drainages. Compaction increases the density of the material and reduces the pore space available to ground water.

6. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed depending on the quality of rock and amount of traffic.

Rocking roads in Dupee soils is necessary irrespective of season of use.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to fileter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Harrington Series (29)

The Harrington series consists of moderately deep, well drained, loamy-skeletal soils formed in colluvial materials derived from gabbro and diorite. They are found on moderately steep to very steep mountainous topography at elevations of 500 to 3,200 feet in areas receiving 70 to 100 inches of precipitation.

Soil Behavior and Recommendations:

The Harrington soils are used for timber production, water supply purposes, and by wildlife. Harrington soils support stands of Douglas-fir with Western hemlock, grand fir, and an understory of vine maple, salal, sword fern, and bracken fern. The average site index is 119 for northerly aspects and is not available for southerly aspects. The timber site class is generally IV for Douglas-fir growing on these soils. The major limitations for timber production are low moisture holding capacity and stoniness associated with these soils. These characteristics when combined with the occurence of Harrington soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly aspects. Soil lost by creep and ravel on steep slopes after clearcutting, vegetative competition and droughty conditions on southerly aspects contribute generally to a poor to fair reforestation success.

The upper 20 inches of Harrington soils have a moderate low water holding capacity. The high amount of coarse fragments, the clay loam to loam texture, and the moderate amount of organic matter blend to produce a water holding capacity that is between 1.5 and 2.5 inches. This amount of moisture is adequate for survival of Douglas-fir seedlings in clearcuts. Clearcutting is recommended on these soils.

Harrington soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Harrington soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations.

However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Harrington soils contain low amounts of organic matter and nitrogen. Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics

are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Harrington soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Harrington soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Harrington soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Hazelair Series (6)

The Hazelair series consists of moderately deep, brown to light gray, moderately well to somewhat poorly drained, silty clay loam to silty clay soils formed in stratified, medium and moderately fine textured and clayey materials occurring on slightly convex footslopes in areas receiving from 30 t 60 inches of annual precipitation. These soils occur on low hills of the eastern footslopes of the Coast Range and western footslopes of the Cascades at elevations of 250 to 2,500 feet.

Soil Behavoir and Recommendations:

Hazelair soils are used for timber production, water supply purposes, recreation, and by wildlife. Hazelair soils support stands of Oregon white oak with poison oak, widely spaced Douglas-fir, rosebush, hazelbrush and grasses. Hazelair soils are not commerical timber-producing soils.

The upper 20 inches of Hazelair soils have a high water holding capacity. The low amount of coarse fragments, the silty clay loam texture of the surface soil plus the clay texture of the subsoil, and the high organic matter content, all blend together to produce a water holding capacity that is between 4.0 and 6.0 inches.

Hazelair soils have an aquic moisture regime and are moderately well to somewhat poorly drained. These soil moisture conditions are highly detrimental to the survival of Douglas-fir seedlings. Douglas-fir grows only in localized pockets of mineral soil having soil moisture conditions that are atypical of these sites. Reforestation efforts have a high liklihood of failure and subsequently, harvesting of Douglas-fir is not recommended.

However, if harvesting of Douglas-fir must take place then the following must be considered:

Hazelair soils are high in clay content. They compact easily from tractor logging. Soil compaction will add substantially to the already critical reforestation properties of these soils. The aquic soil moisture regime of these soils precludes the mitigation of this compaction through ripping. Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs.

2. Permit skidders including low ground pressure tractors only on permanent roads.

3. Gross yard slash to landings.

Moisture conditions on these soils prevent the burning of slash on site and necessitate removal to landings. Moisture conditions in combination with

the high compaction hazard preclude the use of tractors or skidders in yarding or slash removal operations.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on these soils. the topographic position and soil moisture conditions gives Hazelair soils an intrinsically high hazard with respect to the translocation of herbicides to ground or surface water.

Road construction is substantialy complicated by the aquic moisture regime and the poor to somewhat poorly drained properties associated with Hazelair soils. Successful road construction and maintenance requires measures to mitigate the impacts from these properties. Recommendations are:

1. Improve surface drainage, where feasible, by connecting sag ponds and depressions to the nearest stream channel with ditches.

2. Lower the ground water level by means of perforated pipe that is augered into the slope at a slight upward angle. These drains are usually installed in road cutbanks to stabilize areas above an existing road or below roads to stabilize fills.

3. Use rock riprap, or rock buttresses, to provide support for road cuts or fills. Heavy rock riprap replaces the stabilizing weight that is removed by excavation during road construction and it is porous and will allow groundwater to drain out of the slump material.

4. Install interceptor drains to collect the groundwater that is moving laterally downslope, under the road, and saturating the road fill.

5. Compact fills when crossing small drainages. Compaction increases the density of the material and reduces the pore space available to ground water.

6. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed depending on the quality of rock and amount of traffic.

Rocking roads in Hazelair soils is necessary irrespective of season of use.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to fileter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Hembre Series (27)

The Hembre series consists of deep, red, well-drained, fine-loamy soils formed in colluvium from weathered basalt; in areas receiving from 60 to 100 inches of precipitation. They are found on smooth convex ridgetops and strongly sloping to very steep slideslopes and mountains at elevations of 200 to 2,800 feet.

Soil Behavoir and Recommendations:

The Hembre soils are used for timber production, water supply purposes, and by wildlife. Hembre soils support stands of Douglas-fir with Western hemlock, alder, vine maple, salal, sword fern. Site index ranges from 160 to 180 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber producing soils which dominant the Distrist.

Clearcutting is the recommended harvesting practice for Hembre soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Hembre soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Hembre soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in clearcuts. The success of bare-root Douglas-fir seedlings is high.

Hembre soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceeding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Waterbar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also

reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact these soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Hembre soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).
3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Hembre soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Holderman Series (400)

The Holderman series consists of moderately deep, loamy-skeletal brown, cryic soils formed in colluvium from volcanic rocks in areas receiving from 60 to 90 inches of precipitation. These soils occur on gently sloping to steep slopes in the Cascade Mountains at elevations above 2,800 feet.

Soil Behavior and Recommendations:

The Holderman soils are used for timber production, water supply purposes, and by wildlife. Holderman soils support stands of Douglas-fir with Western hemlock, Pacific silver fir, knobcone pine, Western white pine, and an understory of red and blue huckleberry, beargrass, and rhododendron. Average site index is 70 for northerly aspects and 87 for southerly aspects. The timber site class is V for Douglas-fir growing on these soils. Holderman soils are among the least productive and most fragile soils found on the District. The major limitations for timber production are the short growing season, low moisture holding capacity and low fertility associated with these soils. These characteristics when combined with the occurence of Holderman soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly aspects.

The upper 20 inches of Holderman soils have a moderate low water holding capacity. The high amount of coarse fragments, the loam texture, and the moderate amount of organic matter blend to produce a water holding capacity that is between 1.5 and 2.0 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir on all aspects. However, the cold soil and air temperatures and the subsequent short growing season combine with the low moisture holding capacity and low fertility to substantially hinder reforestation efforts. Getting these soils planted in fall is difficult because of early deep snows. Recommendation is to consider spring planting. The success of spring planting will depend on a number of factors, such as how early the snow leaves, how much soil moisture there is at the time of planting and how hot the spring soil temperatures are.

Clearcutting is the recommended harvesting practice for Holderman soils.

Holderman soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area.

Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Holderman soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Holderman soils contain low amounts of organic matter and nitrogen.

Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Holderman soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Holderman soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Holderman soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Honeygrove Series (14)

The Honeygrove series consists of deep, red, well-drained, clayey soils formed in colluvium from basic igneous and sedimentary rocks, in areas receiving from 55 to 90 inches of precipitation. They are found on stable landscapes with nearly level to steep slopes in the Coast Range and Cascade Mountains at elevations of 500 to 2,500 feet.

Soil Behavoir and Recommendations: (Honeygrove soils over sedimentary rock)

The Honeygrove soils are used for timber production, water supply purposes, and by wildlife. Honeygrove soils support stands of Douglas-fir with Western hemlock, Western redcedar, Grand fir, and an understory of vine maple, salal, sword fern, and red huckleberry. Average site index is 175 for northerly and southerly aspects. The timber site class is generally II for Douglas-fir growing on these soils. The stand density is usually normal for Douglas-fir. These soils are among the most highly productive forest soils found in Oregon.

Clearcutting is the recommended harvesting practice for Honeygrove soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Honeygrove soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Honeygrove soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high. Artifical shading is not needed on Honeygrove soils.

Honeygrove soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allow evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Waterbar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue

left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase of rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an edequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction is generally easy in these soils. Crawler tractors equipped with a blade and a ripping attachment are usually adequate for excavation. The material below the soil is usually deeply weathered or highly fractured.

Honeygrove soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Honeygrove soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Soil Behavoir and Recommendations (Honeygrove soils over tuffs and breccias):

All the above statements for Honeygrove soils over sedimentary rock apply to Honeygrove soils over tuffs and breccias with the following exceptions:

1. Honeygrove soils over tuffs and breccias contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. Recommendations is to rock all roads.

2. Cut slopes and fill embankments have a higher incidence of failure.

3. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Soil Behavior and Recommendations (Honeygrove soils over basalt, gabbro, and diorite):

All of the above statements for Honeygrove soils over sedimentatry rock apply to Honeygrove soils over basalt, gabbro, and diorite with the following exceptions:

1. Soils and underlying bedrock are more stable and subsequently the environmental risk from road construction failures is much less.
2. The hazard of sediment from roads, reaching streams is much less.
3. Road construction costs will be much higher as considerably more ripping and blasting will be required.

Hummington Series (40)

The Hummington series consists of moderately deep, loamy-skeletal brown, cryic soils formed in colluvium from volcanic rocks in areas receiving from 60 to 90 inches of precipitation. These soils occur on gently sloping to steep slopes in the Cascade Mountains at elevations above 2,800 feet.

Soil Behavior and Recommendations:

The Hummington soils are used for timber production, water supply purposes, and by wildlife. Hummington soils support stands of Douglas-fir with Western hemlock, noble fir, incense-cedar, chinkapin, knobcone pine, Western white pine, and an understory of red and blue huckleberry, beargrass, vine maple, and rhododendron. Average site index is 70 for northerly aspects and 87 for southerly aspects. The timber site class is V for Douglas-fir growing on these soils. Hummington soils are among the least productive and most fragile soils found on the District. The major limitations for timber production are the short growing season, low moisture holding capacity and low fertility associated with these soils. These characteristics when combined with the occurence of Hummington soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly aspects.

The upper 20 inches of Hummington soils have a moderate low water holding capacity. The high amount of coarse fragments, the loam texture, and the moderate amount of organic matter blend to produce a water holding capacity that is between 2.0 and 3.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir on all aspects. However, the cold soil and air temperatures and the subsequent short growing season combine with the low moisture holding capacity and low fertility to substantially hinder reforestation efforts. Getting these soils planted in fall is difficult because of early deep snows. Recommendation is to consider spring planting. The success of spring planting will depend on a number of factors, such as how early the snow leaves, how much soil moisture there is at the time of planting and how hot the spring soil temperatures are.

Clearcutting is the recommended harvesting practice for Hummington soils.

Hummington soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Hummington soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Hummington soils contain low amounts of organic matter and nitrogen.

Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on Hummington soils. They are somewhat excessively drained, relatively low in clay minerals and subsequently have a low ability to absorb and retain applied chemicals, thus increasing the hazard of herbicides being translocated to ground or surface water reservoirs or streams. Herbicide usage also kills vegetation which through live residual root systems would contribute to slope stability.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Hummington soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Hummington soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Hummington soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Jason Series (64)

The Jason series consists of shallow, well drained, loamy-skeletal soils formed in colluvium from arkosic sandstone. They occur on steep to very steep slopes at elevations of 500 to 3,000 feet in areas having an annual precipitation of 60 to 100 inches.

Soil Behavior and Recommendations:

The Jason soils are used for timber production, water supply purposes, and by wildlife. Jason soils support stands of Douglas-fir with incense-cedar, bigleaf maple, Western hemlock, and an understory of vine maple, salal sword fern, and ocean spray. Average site index is 95 to 110. The timber site class is generally IV for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber producing soils which dominate the District. The shallow depth, high stone content, and low mositure holding capacity of Jason soils are the major limitations to timber production. These characteristics combined with the predominate occurence of Jason soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly exposures. Soil lost by creep and ravel on steep slopes after clearcutting, vegetative competition and droughty conditions on southerly aspects contribute generally to a poor to fair reforestation success.

The upper 20 inches of Jason soils have a low water holding capacity. The high amount of coarse fragments, the silt loam texture, and the moderate amount of organic matter blend to produce a water holding capacity that is between 1.0 and 2.0 and a moisture supplying capacity of 6 to 9 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir in clearcuts on northerly and easterly aspects. It is not adequate for the survival of bare-root Douglas-fir in clearcuts on southerly and westerly aspects. Clearcutting is not recommended on those aspects and partial cutting should not exceed 40 percent of the stand. Clearcutting is recommended for northerly and easterly aspects.

Jason soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. The shallow depth of these soils over weathered sandstone bedrock precludes the mitigation of this compaction through ripping. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Jason soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

Jason soils contain low amounts of organic matter and nitrogen. Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Jason soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Jason soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Jason soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Jory Series (12)

The Jory series consists of deep, well-drained, clayey soils formed in colluvium from basic intrusive igneous and sedimentary rocks in areas receiving from 30 to 50 inches of precipitation. They are found on broad, gently to moderately steep, rounded ridge noses, rolling foothills; and moderately steep side slopes at elevations predominately under 1,200 feet.

Soil Behavoir and Recommendations (Jory soils over sedimentary rock):

The Jory soils are used for timber production, water supply purposes, recreation, and by wildlife. Jory soils support stands of Douglas-fir with incense-cedar, white oak, Pacific madrone, and an understory of poison oak, ocean spray, hazel, salal, and Oregon grape. Site index ranges from 145 to 165 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are typical of the highly productive timber producing soils which dominate the District.

Clearcutting is the recommended harvesting practice for Jory soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Jory soils. Competing vegetation is often a problem. Dense stands of competing brush can get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Jory soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Jory soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimze compaction and A-horizon displacement.

Road construction is generally easy in these soils. Crawler tractors equipped with a blade and a ripping attachment are usually adequate for excavation. The material below the soil is usually deeply weathered or highly fractured.

Jory soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Jory soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Soil Behavior and Recommendations (Jory soils over tuffs and breccias):

All the above statements for Jory soils over sedimentary rock apply to Jory soils over tuffs and breccias with the following exceptions:

1. Jory soils over tuffs and breccias contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. Recommendations is to rock all roads.

2. Cut slopes and fill embankments have a higher incidence of failure.

3. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Soil Behavior and Recommendations (Jory soils over basalt, gabbro, and diorite):

All of the above statements for Jory soils over sedimentary rock apply to Jory soils over basalt, gabbro, and diorite with the following exceptions:

1. Soils and underlying bedrock are more stable and subsequently the environmental risk from road construction failures is much less.

2. The hazard of sediment from roads, reaching streams is much less.

3. Road construction costs will be much higher as considerably more ripping and blasting will be required.

Keel Series (62)

The Keel series consists of moderately deep, very dark brown to brown, gravelly loam soils formed in colluvium weathered from basic igneous rock with some influence of volcanic ash, in areas receiving 70 to 100 inches of precipitation. They occur on gently sloping to very steep slopes in mountainous uplands at elevations of 2,700 to 4,200 feet.

Soil Behavoir and Recommendations:

The Keel soils are used for timber production, water supply purposes, and by wildlife. Keel soils support stands of Douglas-fir with Western hemlock, Western redcedar, Grand fir, and an understory of vine maple, salal, sword fern, and red huckleberry. Site index ranges from 126 to 155 and the timber site class is generally III for Douglas-fir growing on these soils. The major limitations for timber production are the cold soil and air temperatures and subsequent short growing season associated with Keel soils.

Clearcutting is the recommended harvesting practice for Keel soils. These soils occur in moist environments where the growth of Douglas-fir is good.

The upper 20 inches of Keel soils have a high water holding capacity. The moderate amount of coarse fragments, the silt loam texture and the high organic matter content all blend together to produce a water holding capacity that is between 3.0 and 4.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcuts. The success of bare-root Douglas-fir seedlings is high. Getting these soils planted in the fall is difficult because of early deep snows. It is recommended to consider spring planting. However, the success of spring planting will depend on a number of factors such as how early the snow leaves; how much soil moisture there is during and following planting, and how hot the spring temperatures are.

Keel soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allow evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Waterbar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase of rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an edequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Keel soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Keel soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Kilchis Series (35)

The Kilchis series consists of shallow, well or somewhat excessively drained soils formed in colluvial materials derived from gabbro and dioritic rocks in areas receiving from 70 to 100 inches of precipitation. They are found on steep to very steep mountainous topography at elevations above 500 to 3,200 feet.

Soil Behavior and Recommendations:

The Kilchis soils are used for water supply purposes, by wildlife and for timber production except on south exposures and/or in association with major amounts of rock outcrops. Kilchis soils support stands of Douglas-fir with Western hemlock, grand fir, incense-cedar, and an understory of vine maple, salal, sword fern and ocean spray. Average site index is 103 for northerly aspects and 84 for southerly aspects. The timber site class is generally IV or V for Douglas-fir growing on these soils. Kilchis soils are for the most part non-commercial with respect to timber producing capabilities. They are among the most fragile and least productive soils found on the District. The major limitations for timber production are the shallow soil depth, low moisture holding capacity and stoniness associated with these soils. These characteristics combined with the predominate occurrence of Kilchis soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and clearcut logging.

Kilchis soils have a low water holding capacity. The high amount of coarse fragments, the loam texture, and the moderately high amount of organic matter blend to produce a water-holding capacity between 1.0 and 2.0 inches. This amount of moisture is not adequate for survival of bare-root Douglas-fir in clearcuts on southerly and westerly aspects. Clearcutting is not recommended and partial cutting should not not exceed 40 percent of the stand. Clearcutting is recommended on northerly and easterly aspects of Kilchis soils.

When Kilchis soils occur in association with 40 percent or more rock outcrops, they should be considered fragile, noncommercial sites and withdrawn from the commercial timber base.

The physiographic position where the Kilchis soils are most unstable is the drainage headwall. It is characteristically very steep and ground water tends to rise very rapidly during intense storms creating a bouyancy force which can lift the soil free of the slope. The finite balance which exists in headwall positions is frequently upset by road construction and clearcut logging. A sufficient live residual root network must remain following the harvest of timber if massive slope failures are to be avoided in the headwall regions dominated by Kilchis soils. Removal of as little as 38 percent of the stand on these areas has resulted in massive slope failures. Recommendations are to not harvest timber in the headwall regions.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient, ground water rise as related to precipitation, and tree root strength. Kilchis soils are too shallow, too fragile, and too steep for either clearcutting or tractor logging. If timber must be harvested on Kilchis soils then the following is recommended:

1. Require an "on-site" inspection by a soil scientist and geologist to determine slope stability.
2. Require a cable yarding system and full suspension of logs.
3. On southerly aspects: lop and scatter slash on site. Gross yard slash out of headwalls and steep V-shaped drainages to landings using cable system and full suspension.

On northerly aspects: Gross yard slash to landings using cable system and full suspension.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Kilchis soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and/or scarification is not recommended due to the shallow depth, stoniness, and steep togography of Kilchis soils. The subsequent burning of slash in piles will substantially intensify the

impact normally associated with either wildfire or prescribed burning. The concentrating of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

These soils contain low amounts of organic matter and nitrogen. Vegetation succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard basalt. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Kilchis soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and especially in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Kilchis soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.
3. Do not drain roads into concave positions.

Kilchis soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Kinney Series (157)

The Kinney series consists of deep, dark brown, well-drained, cobbly loam and clay loam soils formed in colluvium weathered from coarse grained basic igneous rocks, in areas receiving from 60 to 90 inches of precipitation. They are found on gently sloping to steep upland topography at elevations of 1,000 to 2,500 feet.

Soil Behavoir and Recommendations:

The Kinney soils are used for timber production, water supply purposes, recreation, and by wildlife. Kinney soils support stands of Douglas-fir with Western redcedar, grand fir, incense-cedar, red alder, bigleaf maple, and an understory of vine maple, salal, Oregon grape, sword fern and bracken fern. Site index ranges from 156 to 175 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are typical of the highly productive timber-producing soils which dominate the District.

Clearcutting is the recommended harvesting practice for Kinney soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Kinney soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Kinney soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Kinney soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of tree may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Reuire complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Kinney soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Kinney soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Soil Behavior and Recommendations (Kinney soils over tuffs and breccias):

All the above statements for Kinney soils over ~~sedimentary~~ basic igneous rock apply to Kinney soils over tuffs and breccias with the following exceptions:

1. Kinney soils over tuffs and breccias contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. Recommendations is to rock all roads.

2. Cut slopes and fill embankments have a higher incidence of failure.

3. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Klickitat Series (323)

The Klickitat series consists of deep, reddish brown, loamy-skeletal soils formed in colluvium from basic igneous rocks in areas receiving from 60 to 90 inches of precipitation. They occur on ridges and steep, smooth or dissected slopes in mountainous topography at elevations of 500 to 4,000 feet.

Soil Behavior and Recommendations:

The Klickitat soils are used for timber production, water supply purposes, and by wildlife. Klickitat soils support stands of Douglas-fir with Western hemlock, Western redcedar, grand fir, and an understory of salal, sword fern, vine maple, ocean spray, and red huckleberry. Site index ranges from 135 to 155 and the timber site class is generally III for Douglas-fir growing on these soils. These soils are typical of the highly productive timber producing soils which dominate the District. The major limitations for timber production are the low moisture holding capacity and stoniness associated with these soils. These characteristics when combined with the occurence of Klickitat soils on steep physiographic positions pose substantial hazards to use and management; specifically to road construction.

The upper 20 inches of Klickitat soils have a high water holding capacity. The high amount of coarse fragments, the loam texture of the surface soil plus the silty clay loam texture of the upper part of the subsoil, and the moderate to high organic matter content all blend to produce a water holding capacity that is between 3.0 and 3.5 inches. This amount of moisture is adequate for survival of Douglas-fir bare-root seedlings in clearcuts. The success of bare-root Douglas-fir seedlings is fair to good. Clearcutting is the recommended harvesting practice for Klickitat soils.

Klickitat soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

v, as opposed to burning for site prep.,

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

~~All~~ Burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Klickitat soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations.

However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentrtion of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large mateial that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Klickitat soils contain low amounts of organic matter and nitrogen. Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics

are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction is generally easy. The material below the soil is usually rippable volcanic rocks. Some blasting will be needed on deep cuts. Cut bank stability is high on slopes less than 60 percent, medium on slopes between 60 to 80 percent, and low on slopes over 80 percent.

The most common road failure is from sidecast sluicing out on slopes over 80 percent. Another common failure occurs when a pocket of Klickitat soil is on slopes over 70 percent and a road is built through it. The cut bank slumps, bringing with it large volumes of soil. Recommendations are to carefully locate roads and endhaul on segments with over 80 percent slopes. It is recommended that roads be located on slopes less than 60 percent.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Klickitat soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain road into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

Rocking roads in Klickitat soils is necessary for winter hauling. Either rocking or seeding, mulching, and blocking off temporary spurs is recommended.

Klickitat soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Marty Series (11)

The Marty series consists of deep, well-drained, red, gravelly loam to clay loam soils formed in colluvium from coarse grained intrusive igneous rock in areas receiving 60 to 120 inches of precipitation. They are found on gently broad ridges and steep slopes at elevations of 500 to 3,000 feet.

Soil Behavoir and Recommendations:

Marty soils are used for timber production, water supply purposes, recreation, and by wildlife. Marty soils support stands of Douglas-fir with Western hemlock, noble fir, alder and an understory of vine maple, sword fern, Oregon grape, and salal. Site index ranges from 135 to 155 and the timber site class is generally III for Douglas-fir growing on these soils.

Clearcutting is the recommended harvesting practice for Marty soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Marty soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Marty soils have a high water holding capacity. The moderate amount of coarse fragments, the clay loam texture of the surface soil and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Marty soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and retrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental or a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Marty soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Marty soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

McCully Series (111)

The McCully series consists of deep, red, well-drained clayey soils formed in colluvium and residuum from basic igneous rocks in areas receiving from 80 to a c inches of precipitation. They occur on moderately sloping to steep uplands in the Coast Range at elevations 800 to 2,500 feet.

Soil Behavoir and Recommendations:

The McCully soils are used for timber production, water supply purposes, and by wildlife. McCully soils support stands of Douglas-fir with Western hemlock, Western redcedar, and an understory of cascara, salal, vine maple, bracken fern, and sword fern. Site index ranges from 156 to 175 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are among the most highly productive forest soils found in Western Oregon.

Clearcutting is the recommended harvesting practice for McCully soils. These soils occur in cool moist environments where the growth of Douglas-fir is good.

The upper 20 inches of McCully soils have a high water holding capacity. The low amount of coarse fragments, the clay loam textures, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in clearcuts. The success of bare-root Douglas-fir seedlings is high.

McCully soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

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4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceeding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Waterbar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantailly to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil moisture.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowahce again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

McCully soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

McCully soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Minniece Series (6)

The Minniece series consists of deep, grayish brown and gray, poorly and somewhat poorly drained, silty loam to silty clay soils formed in colluvium and alluvium from basic igneous rocks including tuffs and breccia in areas receiving from 60 to 90 inches of precipitation. They are found on depressional areas and narrow drainageways at elevations of 800 to 3,000 feet.

Soil Behavoir and Recommendations:

Minniece soils are used for timber production, water supply purposes, recreation, and by wildlife. Minniece soils support stands of Douglas-fir, alder, maple, willow, Oregon ash, Western redcedar, Western hemlock with an understory of sword fern, willow sedges, grass, and skunk cabbage. Site index ranges from 135 to 150 and the timber site class is generally III for Douglas-fir growing on these soils.

The upper 20 inches of Minniece soils have a high water holding capacity. The low amount of coarse fragments, the silt clay loam texture of the surface soil plus clay texture of the upper part of the subsoil, and high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 7.5 inches.

Minniece soils have an aquic moisture regime and are poorly to somewhat poorly drained. These moisture conditions are highly detrimental to the for the survival of Douglas-fir seedlings. Douglas-fir naturally grows only in isolated pockets of soil having soil moisture conditions that are atypical of these sites. Reforestation efforts are likely to fail and it is subsequently recommended that Douglas-fir not be harvested on these soils.

However, if harvesting of Douglas-fir must take place then the following must be considered:

Minniece soils are high in clay content. They compact easily from tractor logging. Soil compaction will add substantially to the already critical reforestation properties of these soils. The aquic soil moisture regime of these soils precludes the mitigation of compacting by ripping. Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs.

2. Permit skidders including low ground pressure tractors only on permanent roads.

3. Gross yard slash to landings.

Moisture conditions on these soils prevent the burning of slash on site and necessitate removal to landings. Moisture conditions in combination with

the high compaction hazard preclude the use of tractors or skidders in yarding or slash removal operations.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on these soils. The topographic position and soil moisture conditions gives Minniece soils an intrinsically high hazard with respect to the translocation of herbicides to ground or surface water.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to fileter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Road construction is substantially complicated by the aquic moisture regime and the poor to somewhat poorly drained properties associated with Minniece soils. Successful road construction and maintenance requires measures to mitigate the impact from these properties. Recommendations are:

1. Improve surface drainage, where feasible, by connecting sag ponds and depressions to the nearest stream channel with ditches.

2. Lower the ground water level by means of perforated pipe that is augered into the slope at a slight upward angle. These drains are usually installed in road cutbanks to stabilize areas above an existing road or below roads to stablize fills.

3. Use rock riprap, or rock buttresses, to provide support for road cuts or fills. Heavy rock riprap replaces the stabilizing weight that is removed by excavation during road construction and it is porous and will allow groundwater to drain out of the slump material.

4. Install interceptor drains to collect the groundwater that is moving laterally downslope, under the road, and saturating the road fill.

5. Compact fills when crossing small drainages. Compaction increases the density of the material and reduces the pore space available to ground water.

6. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed depending on the quality of rock and amount of traffic.

Rocking roads in Minniece soils is necessary irrespective of season of use.

MIXED ALLUVIAL LAND (1)

This mapping unit, a miscellaneous land type, encompasses all floodplains and alluvial bottom lands within the District. This land type is dominated by deep to very deep, somewhat poorly to somewhat excessively drained, coarse to fine textured soils formed in recent alluvium derived from predominately basic igneous rocks. It occurs on nearly level bottom lands, gently undulating high floodplains and terraces at elevations ranging from 300 to 1,500 feet. Annual precipitation ranges from 40 to 80 inches.

This land type contains the Abiqua, Cloquato, Jimbo, McAlpin, Meda, Nehalem, Nestucca, Veneta, Saturn, and Sifton soil series. As a result of steep slopes and the general topography of the District, these soils account for only a very limited amount of the total District acreage. However, in spite of the limited acreage of this land type, it is the most important land type in the District with respect to watershed and wildlife resources.

Soil Behavoir and Recommendations:

Mixed Alluvial Land is used for water supply purposes, recreation, timber production, and by wildlife. Mixed Alluvial Land supports stands of Douglas-fir with Oregon white oak, Oregon ash, bigleaf maple, Western redcedar, Western hemlock, dogwood, cottonwood, red alder, Grand fir, and an understory of devil's club, salmonberry, rushes, vine maple, blackberry, salal, sword fern, sedges, bracken fern, and hazel. Site index ranges from 151 to 166 and the timber site class is generally II for Douglas-fir growing on these soils. This land type is made up of the most productive soils found on the District with respect to total biomass and also with respect to the variety of species present.

Mixed Alluvial Land is the single most important land type from the standpoint of water resources protection and enhancement.

Mixed Alluvial Land is also the single most important land type with respect to wildlife habitat. Abused, it will result in a highly significant reduction in wildlife potential in terms of the number of species present and in terms of population sizes.

Available water holding capacity ranges from 6 to 15 inches and water supplying capacity ranges from 20 to 26 inches. Effective rooting depth ranges from 40 to more than 60 inches; though in some soils of Mixed Alluvial Land, this is restricted by a seasonally high water table or thin soil mantle. Soil moisture is adequate for the survival of bare-root Douglas-fir, though flooding and high water tables are a problem on many of these soils and plant competition is generally severe.

Clearcutting is not recommended as the disruption of transpiration could create soil moisture conditions precluding regeneration and the impacts on

watershed stability, water quality, and wildlife habitat could be substantial.

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on Mixed Alluvial Land. The genesis, topographic position and functional nature of this land type from a watershed standpoint; gives Mixed Alluvial Land an intrinsically high hazard with respect to the translocation of herbicides to ground or surface water.

Mixed Alluvial Land is highly variable with respect to properties affecting the location and construction of roads and exceptional planning and care is necessary to avoid detrimental impacts to soil, water, and wildlife resources.

Mulkey Series (42)

The Mulkey series consists of moderately deep, loam, brown, cryic soils formed in medium textured colluvium from intrusive igneous rocks with an influence of volcanic ash, in areas receiving from 60 to 120 inches of precipitation. They occur on gently sloping to very steep mountainous uplands at elevations of 3,000 to 4,000 feet.

Soil Behavior and Recommendations:

The Mulkey soils are used for timber production, water supply purposes, and by wildlife. Mulkey soils generally are grass covered with scattered bracken fern. Scattered Douglas-fir and Western hemlock occur on these soils but they are not generally commercial stands. Site index ranges from 75 to 95 and the timber site class is generally V for Douglas-fir growing on these soils. The major limitations for timber production are the cold soil and air temperatures and subsequent short growing season associated with these soils.

The upper 20 inches of Mulkey soils have a high water holding capacity. The moderate amount of coarse fragments, the loam texture, and the moderate amount of organic matter blend to produce a water holding capacity that is between 3.5 and 4.5 inches.

Mulkey soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly

aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.
2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains oragnic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Mulkey soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site

productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildlife or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.
2. Strict enforcement of soil moisture restrictions on tractor piling activities.
3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.
4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.
5. Burning of the wind-rows during periods of high soil moisture.
6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Mulkey soils contian low amounts of organic matter and nitrogen.

Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires blasting. The material below the soil is usually hard gabbro or dioritic rock. Cut bank stability is high. Recommendations are:

1. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

Road construction can cause severe erosion on Mulkey soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Mulkey soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

3. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with a U-shaped blade and scrapers.

4. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

3. Do not drain roads into concave positions.

Mulkey soils are poorly suited for helipond locations due to seepage and depth to bedrock. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Nekia Series (23)

The Nekia series consists of moderately deep, well-drained, red, silty clay loam over clay soils formed in fine textured colluvium derived from basic igneous rocks in areas receiving from 35 to 60 inches of precipitation. They occur on gently sloping and rolling foothills and moderately steep to steep mountain slopes at elevations of 500 to 3,200 feet.

Soil Behavoir and Recommendations:

The Nekia soils are used for timber production, water supply purposes, recreation, and by wildlife. Nekia soils support stands of Douglas-fir with incense-cedar, Oregon white oak, madrone, grand fir, and an understory of posion oak, ocean spray, bracken fern, hazel, vine maple, salal, and Oregon grape. Site index ranges from 144 to 159 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber producing soils which dominant the District.

Clearcutting is the recommended harvesting practice for Nekia soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Nekia soils. Competing vegetation is often a problem. Dense stands of competing brush can get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Nekia soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Nekia soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of

transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimze compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Nekia soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Nekia soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Panther Series (8)

The Panther series consists of deep, brown, poorly drained, silty clay loam to clay soils formed in weathered sedimentary rocks in areas receiving from 40 to 60 inches of precipitation. They occur in swales and concave slopes on low foothills at elevations of 200 to 1,200 feet.

Soil Behavoir and Recommendations:

Panther soils are used for timber production, water supply purposes, recreation, and by wildlife. Panther soils support stands of Oregon white oak with poison oak, rosebush, grasses and sedges. Panther soils are not commercial timber-producing soils.

The upper 20 inches of Panther soils have a high water holding capacity. The low amount of coarse fragments, the silty clay loam and clay textures, the predominance of montmorillonitic clay mineralogy; and the high organic matter content, all blend together to produce a water holding capacity that is between 6.5 and 8.0 inches.

Panther soils have an aquic moisture regime and are poorly drained. These soil moisture conditions are not adequate for the survival of Douglas-fir seedings. Douglas-fir grows only in isolated pockets of soil having soil moisture conditions that are atypical of these sites. Reforestation efforts are likely to fail and it is subsequently recommended that Douglas-fir not be harvested on these soils.

Road construction is substantially complicated by the aquic moisture regime, montmorillonitic clay, and the poor drainage characteristics associated with Panther soils. When the montmorillonitic clay of these soils becomes saturated, it cause a significant decrease in slope stability as a result of the very low sheer strength and high shrink-swell potential. Successful road construction and maintenance requires exceptional efforts to mitigate the influence of these properties. Recommendations are:

1. Improve surface drainage, where feasible, by connecting sag ponds and depressions to the nearest stream channel with ditches.

2. Lower the ground water level by means of perforated pipe that is augered into the slope at a slight upward angle. These drains are usually installed in road cutbanks to stabilize areas above an existing road or below roads to stablize fills.

3. Use rock riprap, or rock buttresses, to provide support for road cuts or fills. Heavy rock riprap replaces the stabilizing weight that is removed by excavation during road construction and it is porous and will allow groundwater to drain out of the slump material.

4. Install interceptor drains to collect the groundwater that is moving laterally downslope, under the road, and saturating the road fill.

5. Compact fills when crossing small drainages. Compaction increases the density of the material and reduces the pore space available to ground water.

6. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed depending on the quality of rock and amount of traffic.

7. Minimize height of fills. Panther soils have a high shrink-swell potential; are highly susceptible to cracking; and are difficult to compact.

Rocking roads in Panther oils is necessary irrespective of season of use.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75 percent of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10 percent.

Peavine Series (20)

The Peavine series consists of moderately deep, well-drained, red, clayey soils formed in colluvium from basic igneous and sedimentary rocks in areas receiving from 50 to 90 inches of precipitation. These soils are predominantly found on slopes of less than 60 percent at elevations of 400 to 2,500 feet.

Soil Behavoir and Recommendations:

The Peavine soils are used for timber production, water supply purposes, recreation, and by wildlife. Peavine soils support stands of Douglas-fir with Western redcedar, incense-cedar, red alder, bigleaf maple, Western hemlock and an understory of vine maple, salal, ocean spray, sword fern, and red huckleberry. Site index ranges from 150 to 175 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are typical of the highly productive timber producing soils which dominate the District.

Clearcutting is the recommended harvesting practice for Peavine soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Peavine soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Peavine soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Peavine soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Peavine soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Peavine soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Soil Behavior and Recommendations (Peavine soils over tuffs and breccias):

All the above statements for Peavine soils over sedimentary rock apply to Peavine soils over tuffs and breccias with the following exceptions:

1. Peavine soils over tuffs and breccias contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. Recommendations is to rock all roads.

2. Cut slopes and fill embankments have a higher incidence of failure.

3. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Soil Behavior and Recommendations (Peavine soils over basalt, gabbro, and diorite):

All of the above statements for Peavine soils over sedimentary rock apply to Peavine soils over basalt, gabbro, and diorite with the following exceptions:

1. Soils and underlying bedrock are more stable and subsequently the environmental risk from road construction failures is much less.

2. The hazard of sediment from roads, reaching streams is much less.

3. Road construction costs will be much higher as considerably more ripping and blasting will be required.

Philomath Series (28)

The Philomath series consists of shallow, very dark brown, well drained, clayey soils formed in colluvium weathered from basic igneous rocks in areas receiving from 30 to 60 inches of precipitation. They are on convex foothills at elevations of 350 to 2,000 feet.

Soil Behavoir and Recommendations:

The Philomath soils are used for timber production, water supply purposes, recreation, and by wildlife. Philomath soils support a vegetative cover of grass, wild rose, and poison oak with a few patches of Oregon white oak. Philomath soils are not suitable for timber production.

The upper 20 inches of Philomath soils have a high water holding capacity. The low amount of coarse fragments; clay textures; preponderance of montmorillonitic clays; and the high organic matter content all blend together to produce a water holding capacity that is between 3.0 and 4.0 inches.

Commerical stands of timber are generally not found on these soils. Philomath soils are high in clay content. They compact easily from tractor logging. When commercial stands are found on Philomath soils, the following is recommended:

1. Require a cable yarding system and at least partial suspension of logs.

2. Permit skidders including low ground pressure tractors only on permanent roads.

3. Gross yard slash to landings.

The high compaction hazard associated with these soils precludes the use of tractors or skidders, in either yarding or slash removal. The montmorillonitic mineralogy precludes the mitigation of compaction by ripping.

Road construction requires mostly blasting. Ther material below the soil is usually hard basalt. Cut bank stability is high. The most common failure is sidecast sluicing out.

When the montmorillonitic clay of Philomath series becomes saturated, it causes a significant decrease in slope stability as a result of the very low shear strength and high shrink-swell potential.

When constructing roads in these soils the following is recommended:

1. Minimize height of fills. Philomath soils have a high shrink-swell potential; are highly susceptible to cracking; and are difficult to compact.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

3. Do not drain roads into concave positions.

Philomath soils are poorly suited for helipond locations because they are shallow over hard bedrock. Ponds will not hold water if allowed to dry out. They are poorly suited for material to construct small dams because of a high shrink-swell potential shallow depth to bedrock, low compactability and presence of cobbles.

Preacher Series (57)

The Preacher series consists of moderately deep, well-drained, brown, loam soils developed in colluvium derived from arkosic sandstone in areas receiving from 80 to 100 inches of precipitation. They occur on gently sloping to steep slopes at elevations of 500 to 2,500 feet.

Soil Behavoir and Recommendations:

The Preacher soils are used for timber production, water supply purposes, recreation, and by wildlife. Preacher soils support stands of Douglas-fir with Western hemlock, Western redcedar, grand fir, and an understory of sword fern, vine maple, salal. Site index ranges from 156 to 176 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are among the most productive forest soils in Western Oregon.

Clearcutting is the recommended harvesting practice for Preacher soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Preacher soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Preacher soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in clearcuts. The success of bare-root Douglas-fir seedlings is high.

Preacher soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area.

Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination

with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

3. Strict enforcement of soil moisture restrictions on tractor piling activities.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding

requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Preacher soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter

through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Preacher soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Ritner Series (24)

The Ritner series consists of deep, red, clayey-skeletal soils from volcanic rock colluvium in areas receiving from 35 to 50 inches of precipitation. They occur on steep to very steep slopes in the Cascade Mountains at elevations of 500 to 2,000 feet.

Soil Behavoir and Recommendations:

The Ritner soils are used for timber production, water supply purposes, and by wildlife. Ritner soils support stands of Douglas-fir with bigleaf maple, Oregon white oak, incense-cedar, ponderosa pine, and an understory of poison oak, hazel, bracken fern, and ocean spray. Site index ranges from 115 to 135 and the timber site class is generally III or IV for Douglas-fir growing on these soils.

The upper 20 inches of Ritner soils have a moderate to low water holding capacity. The high amount of coarse fragments, the clay or clay loam texture, and the low amount of organic matter content all blend together to produce a water holding capacity that is between 1.5 and 2.5 inches. This amount of moisture is adequate for survival of Douglas-fir bare-root stock on northly and easterly aspects. This is not adequate for the survival of Douglas-fir bare-root stock on southerly and westerly aspects. It is recommended not to clearcut southerly and westerly aspects of Ritner soils and to restrict partial cutting to less than 40 percent of the stand. Clearcutting is recommended on northerly and easterly aspects.

When dense stands of competing brush become established after a burn or clearcut, it is recommended to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

Ritner soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration proceesses of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceeding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also

reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Ritner soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in

the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Ritner soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Slickrock Series (54)

The Slickrock series consists of deep, well-drained, brown, fine-loamy soils formed in colluvium derived from sedimentary rocks in areas receiving from 60 to 120 inches of precipitation. They occur on gently sloping to steep mountain slopes and dissected slumps at elevations of 500 to 2,500 feet.

Soil Behavoir and Recommendations:

The Slickrock soils are used for timber production, water supply purposes, recreation, and by wildlife. Slickrock soils support stands of Douglas-fir with Western hemlock, and an understory of sword fern, vine maple, salal, red huckleberry, Oregon grape, and salmonberry. Site index ranges from 170 to 185 and the timber site class is generally II for Douglas-fir growing on these soils. These soils are among the most productive forest soils in Western Oregon.

Clearcutting is the recommended harvesting practice for Slickrock soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Slickrock soils. Competing vegetation is usually not a problem. Occasionally, a very dense stand of competing brush will get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Slickrock soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 5.5 and 7.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Slickrock soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high-lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yrading requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon placement.

Road construction requires mostly blasting. The material below the soil is usually hard basalt.

Slickrock soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Slickrock soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

UMPCOOS SERIES (564)

The Umpcoos series consists of shallow, well or somewhat excessively drained, loamy-skeletal soils developed in colluvium derived from sandstone in areas receiving from 60 to 100 inches of precipitation annually. They occur on steep and very steep slopes and headwalls at elevations ranging from 500 to 2,500 feet.

Soil Behavior and Recommendations:

The Umpcoos soils are used for water supply purposes, by wildlife, and for timber production except when in association with major (40%) amounts of rock outcrops. Umpcoos soils support stands of Douglas-fir with understory of Oregon grape, sword fern, salal, ocean spray, vine maple. Average site index is 88 for both northerly and southerly aspects. The timber site class is generally V for Douglas-fir growing on these soils. Umpcoos soils are among the most fragile and least productive soils found on the District. It is recommended that the frequency of cutting cycles and length of rotations be extended until they accurately reflect the lower productivity potential of these soils. The factors limiting timber production are the shallow soil depth, low moisture holding capacity and stoniness. These characteristics combined with the predominate occurrence of Umpcoos soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcut logging. The high amount of coarse fragments, the loamy texture, and the low amount of organic matter produce a water holding capacity that is between 1.0 to 2.0 inches. This amount of moisture is not adequate for survival of bare-root Douglas-fir in clearcuts on southerly and westerly aspects. Clearcutting is not recommended and partial cutting should not exceed 40 percent of the stand. This amount of moisture is adequate for survival of bare-root Douglas-fir in clearcuts on northerly and easterly aspects. However, the overall lack of slope stability on Umpcoos soils is sufficiently critical to preclude clearcutting even on these aspects. Partial cutting should not exceed 40 percent of the stand.

When Umpcoos soils occur in association with 40 percent or more rock outcrops, they should be considered fragile, noncommercial sites and withdrawn from the commercial timber base.

The physiographic position where the Umpcoos soils are most unstable is the drainage headwall. It is characteristically very steep and ground water tends to rise very rapidly during intense storms creating a bouyancy force which can lift the soil free of the slope. The finite balance which exists in headwall positions is frequently upset by road construction and clearcut logging. A sufficient live residual root network must remain following the harvest of timber if massive slope failures are to be avoided in the headwall regions dominated by Umpcoos soils. Removal of as little as 38 percent of the stand on these areas has resulted in massive slope failures. Recommendations are to not harvest timber in the headwall regions.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient, ground water rise as related to precipitation, and tree root strength. Umpcoos soils are too shallow, too fragile, and too steep for either clearcutting or tractor logging. If timber must be harvested on Umpcoos soils then the following is recommended:

1. Require an "on-site" inspection by a soil scientist and forester to determine the gross tree volume and average tree spacing necessary to maintain a slope stability factor of 1.1 or greater (Burroughs and Thomas, 1976) and design timber sales accordingly.

2. Require a cable yarding system and full suspension of logs.

3. On southerly aspects: lop and scatter slash on site. Gross yard slash out of headwalls and steep V-shaped drainages to landings using cable system and full suspension.

On northerly aspects: Gross yard slash to landings using cable system and full suspension.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Umpcoos soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and/or scarification is not recommended due to the shallow depth, stoniness, and steep togography of Umpcoos soils. The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentrating of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

These soils contain low amounts of organic matter and nitrogen. Vegetation succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Umpcoos soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and especially in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Umpcoos soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

3. Do not drain roads into concave positions, e.g. headwalls.

Umpcoos soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Unnamed Unit 166 Series

The Unit 166 series consists of moderately deep, well drained, brown, loamy-skeletal soils formed in colluvium from arkosic sandstone. They occur on steep to very steep mountainous uplands at elevations of 200 to 3,000 feet in areas having an annual precipitation of 60 to 100 inches.

Soil Behavior and Recommendations:

The Unit 166 soils are used for timber production, water supply purposes, and by wildlife. Unit 166 soils support stands of Douglas-fir with bigleaf maple, red alder, and either an understory of vine maple-salal or ocean spray-salal. The site index is estimated to range from 120 to 140 and the timber site class is generally III for Douglas-fir growing on these soils. These soils are typical of the highly productive, timber producing soils which dominate the District. The major limitations for timber production are the low moisture holding capacity and stoniness associated with these soils. These characteristics combined with the predominate occurence of Unit 166 soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and to clearcutting on southerly exposures. Soil lost by creep and ravel on steep slopes after clearcutting, vegetative competition and droughty conditions on southerly aspects contribute generally to a poor to fair reforestation success.

The upper 20 inches of Unit 166 soils have a moderate water holding capacity. The high amount of coarse fragments, the loam or silt textures, and the moderate amount of organic matter blend to produce a water holding capacity that is between 3.0 and 4.0 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir in clearcuts. Clearcutting is recommended on Unit 166 soils.

Unit 166 soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and subsequent reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35 percent, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.
2. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors or skidders.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Unit 166 soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations.

However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Scarification and/or machine piling of slash are not recommended. These cultural practices are detrimental to the soil resource and site productivity. Even the coarse-textured soils are susceptible to significant levels of compaction and subsequent losses in site productivity. The burning of slash in piles will substantially intensify the negative impacts normally associated with wildfire or prescribed burning.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Unit 166 soils contain low amounts of organic matter and nitrogen. Vegetative succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics

are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard sandstone. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Unit 166 soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and specifically in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Unit 166 soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 15%.

3. Do not drain roads into concave positions.

Unit 166 soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

WillaKenzie Series (67)

The Willakenzie series consists of deep, well-drained, fine-silty soils in sedimentary rocks in areas receiving from 40 to 50 inches of precipitation. They are found on gently sloping to steep convex slopes in uplands at elevations 250 to 1,400 feet.

Soil Behavoir and Recommendations:

The Willakenzie soils are used for timber production, water supply purposes, recreation, and by wildlife. Willakenzie soils support stands of Douglas-fir with Oregon white oak, bigleaf maple, and an understory of poison oak, rosebush, and annual and perennial grasses. Site index ranges from 142 to 165 and the timber site class is generally II or III for Douglas-fir growing on these soils. These soils are typical of the highly productive timber producing soils which dominate the District.

Clearcutting is the recommended harvesting practice for Willakenzie soils. These soils occur in moist environments where the growth of Douglas-fir is good. Aspect does not play a strong role in tree growth on Willakenzie soils. Competing vegetation is often a problem. Dense stands of competing brush can get established after a burn or clearcut. Recommendations are to utilize spot burning and spot spraying for site preparation in order to get Douglas-fir stocked within five years after harvesting and with minimal disturbance to the soil resource.

The upper 20 inches of Willakenzie soils have a high water holding capacity. The low amount of coarse fragments, the clay loam or clay texture of the surface soil plus the clay texture of the upper part of the subsoil, and the high organic matter content all blend together to produce a water holding capacity that is between 4.5 and 5.5 inches. This amount of moisture is adequate for survival of bare-root Douglas-fir seedlings in a clearcut. The success of bare-root Douglas-fir seedlings is high.

Willakenzie soils are high in clay content. They compact easily from tractor logging. Soil compaction on these soils will significantly reduce the volume and height growth of Douglas-fir resulting in a reduction in timber site class. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

3. Plan all primary skid trails prior to loggin operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

4. Require felling of trees to lead to the skid trails to reduce ground area covered by tractors.

5. Allow tractors to operate only when the soil moisture is 25 percent or less, usually from July 15 to October 1 on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may even prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be reached.

6. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of 15 inches with ripped furrows no farther apart than 18 inches, center to center. Water bar all major skid trails.

When yarding is to be accomplished with a high lead cable system rather than the low ground-pressure tractors, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense

living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in ground water in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events. Recommendations are to restrict burning to landings and/or to spot burn less than 10% of the area yarded.

Prescribed area or broadcast burning may be necessary on some sites to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and brush and/or scarification is not recommended due to the clayey textures of these soils. Machine piling, irrespective of season applied, will lead to a high initial increase in the density of the surface two to four inches of soil over the full area treated. The surface compaction will lead to an increase in the volume and velocity of runoff, thus encouraging erosion. Machine piling will deeply compact those soils around the bunched piles. The resulting loss in pore space around the piles closely correlates with that experienced in heavily used skidding roads in tractor logged units. This will severely restrict movement of water and air leading to an imbalance in the CO_2-O_2 ratio best suited for planted seedlings, thereby, lowering site productivity. Roots attempting to elongate into compacted soil will be deformed and a reduction in growth rates occur.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentration of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

If satisfactory alternatives to machine piling and burning do not exist for a specific site to facilitate reforestation, then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour, constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Burning of the wind-rows during periods of high soil moisture.

6. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations. This should minimize compaction and A-horizon displacement.

Road construction is generally easy in these soils. Crawler tractors equipped with a blade and a ripping attachment are usually adequate for excavation. The material below the soil is usually deeply weathered or highly fractured.

Willakenzie soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise. It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in

the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and fill slopes).

3. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

Fire trails that are built by hand result in little disturbance. If tractors must be used to construct fire trails, then restrict to slopes less than 10% and build closely spaced waterbars.

Willakenzie soils are well suited for helipond locations and material to construct small earth dams. The material compacts easily when at optimum moisture. The subsoil is well suited to be used as a sealer for pond bottoms. Usually six to ten inches of compacted subsoil is adequate.

Winberry Series (410)

The Winberry series consists of shallow, loamy-skeletal, brown, cryic soils formed in colluvium from volcanic rocks in areas receiving from 60 to 90 inches of precipitation. They occur on ridgetops and slideslopes in the Cascade Mountains at elevations above 2,800 feet.

Soil Behavior and Recommendations:

The Winberry soils are used for water supply purposes, by wildlife and for timber production except on south exposures and/or in association with major amounts of rock outcrops. Winberry soils support stands of Douglas-fir with Western hemlock, Pacific silver fir, knobcone pine, Western white pine, and an understory of blue and red huckleberry, beargrass and rhododendron. Average site index is not available for northerly aspects and is 78 for southerly aspects. The timber site class is generally V for Douglas-fir growing on these soils. Winberry soils are for the most part non-commercial with respect to timber producing capabilities. They are among the most fragile and least productive soils found on the District. The major limitations for timber production are the shallow soil depth, low moisture holding capacity and stoniness associated with these soils. These characteristics combined with the predominate occurrence of Winberry soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and clearcut logging.

Winberry soils have a low water holding capacity. The high amount of coarse fragments, the loam texture, and the moderately high amount of organic matter blend to produce a water-holding capacity between 1.0 and 1.5 inches. This amount of moisture is not adequate for survival of bare-root Douglas-fir in clearcuts on southerly and westerly aspects. On northerly and easterly aspects, cold soil and air temperatures and the subsequent short growing season combine with the low moisture holding capacity and low fertility normally associated with these soils to substantially hinder reforestation efforts. Clearcutting is not recommended on Winbery soils and it is recommended that partial cutting not exceed 40 percent of the stand.

When Winberry soils occur in association with 40 percent or more rock outcrops, they should be considered fragile, noncommercial sites and withdrawn from the commercial timber base.

The physiographic position where the Winberry soils are most unstable is the drainage headwall. It is characteristically very steep and ground water tends to rise very rapidly during intense storms creating a bouyancy force which can lift the soil free of the slope. The finite balance which exists in headwall positions is frequently upset by road construction and clearcut logging. A sufficient live residual root network must remain following the harvest of timber if massive slope failures are to be avoided

in the headwall regions dominated by Winberry soils. Removal of as little as 38 percent of the stand of these areas has resulted in massive slopes failures. Recommendations are to not harvest timber in the headwall regions.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient, ground water rise as related to precipitation, and tree root strength. Winberry soils are too shallow, too fragile, and too steep for either clearcutting or tractor logging. If timber must be harvested on Winberry soils then the following is recommended:

1. Require an "on-site" inspection by a soil scientist and geologist to determine slope stability.

2. Require a cable yarding system and full suspension of logs.

3. On southerly aspects: lop and scatter slash on site. Gross yard slash out of headwalls and steep V-shaped drainages to landings using cable system and full suspension.

On northerly aspects: Gross yard slash to landings using cable system and full suspension.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Winberry soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations.

However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and/or scarification is not recommended due to the shallow depth, stoniness, and steep togography of Winberry soils. The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentrating of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

These soils contain low amounts of organic matter and nitrogen. Vegetation succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard basalt. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Winberry soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and especially in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Winberry soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

3. Do not drain roads into concave positions.

Winberry soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Witzel Series (36)

The Witzel series consists of shallow, well drained stony soils developed in colluvium from basic igneous rock in areas receiving from 35 to 50 inches of precipitation. They occur on moderately steep to very steep mountainous topography at elevations above 700 to 1,650 feet.

Soil Behavior and Recommendations:

The Witzel soils are used for water supply purposes, by wildlife and for timber production except on south exposures and/or in association with major amounts of rock outcrops. Witzel soils support stands of Douglas-fir with madrone, Oregon white oak, incense-cedar, and an understory of poison oak, ocean spray, hazel, salal, Oregon grape and vine maple. Site index ranges from 90 to 105 and the timber site class is generally V for Douglas-fir growing on these soils. Witzel soils are for the most part non-commercial with respect to timber producing capabilities. They are among the most fragile and least productive soils found on the District. The major limitations for timber production are the shallow soil depth, low moisture holding capacity and stoniness associated with these soils. These characteristics combined with the predominate occurrence of Witzel soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and clearcut logging.

Witzel soils have a low water holding capacity. The high amount of coarse fragments, the loam texture, and the moderately high amount of organic matter blend to produce a water-holding capacity between 0.5 and 1.5 inches. This amount of moisture is not adequate for survival of bare-root Douglas-fir in clearcuts. Clearcutting is not recommended and partial cutting should not exceed 40 percent of the stand.

When Witzel soils occur in association with 40 percent or more rock outcrops, they should be considered fragile, noncommercial sites and removed from the allowable cut base. It is recommended that the volume per acre that normal yield tables say will be produced, be reduced. Frequently these soils produce about 60 percent of normal volume.

The physiographic position where the Witzel soils are most unstable is the drainage headwall. It is characteristically very steep and ground water tends to rise very rapidly during intense storms creating a bouyancy force which can lift the soil free of the slope. The finite balance which exists in headwall positions is frequently upset by road construction and clearcut logging. A sufficient live residual root network must remain following the harvest of timber if massive slope failures are to be avoided in the headwall regions dominated by Witzel soils. Removal of as little as 38 percent of the stand on these areas has resulted in massive slope failures. Recommendations are to not harvest timber in the headwall regions.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient, ground water rise as related to precipitation, and tree root strength. Witzel soils are too shallow, too fragile, and too steep for either clearcutting or tractor logging. If timber must be harvested on Witzel soils then the following is recommended:

1. Require an "on-site" inspection by a soil scientist and geologist to determine slope stability.
2. Require a cable yarding system and full suspension of logs.
3. On southerly aspects: lop and scatter slash on site. Gross yard slash out of headwalls and steep V-shaped drainages to landings using cable system and full suspension.

On northerly aspects: Gross yard slash to landings using cable system and full suspension.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Witzel soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and/or scarification is not recommended due to the shallow depth, stoniness, and steep togography of Witzel soils. The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentrating of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

These soils contain low amounts of organic matter and nitrogen. Vegetation succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive and absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard basalt. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Witzel soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and especially in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Witzel soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

3. Do not drain roads into concave positions.

Witzel soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

Yellowstone Series (41)

The Yellowstone series consists of shallow, loamy-skeletal, dark brown, cryic soils formed in colluvium and residuum weathered from basalt in areas receiving from 70 to 150 inches of precipitation. They occur on mountainous uplands at elevations ranging from 2,200 to 4,000 feet.

Soil Behavior and Recommendations:

The Yellowstone soils are used for water supply purposes, by wildlife and for timber production except on south exposures and/or in association with major amounts of rock outcrops. Yellowstone soils support stands of Douglas-fir with Western hemlock, silver fir, Western white pine, and an understory of blue and red huckleberry, beargrass and rhododendron. Site index ranges from 66 to 95 and the timber site class is generally V for Douglas-fir growing on these soils. Yellowstone soils are for the most part non-commercial with respect to timber producing capabilities. They are among the most fragile and least productive soils found on the District. The major limitations for timber production are the shallow soil depth, low moisture holding capacity and stoniness associated with these soils. These characteristics combined with the predominate occurrence of Yellowstone soils on steep physiographic positions pose many hazards to use and management; specifically to road construction and clearcut logging.

Yellowstone soils have a low water holding capacity. The high amount of coarse fragments, the loam texture, and the moderately high amount of organic matter blend to produce a water-holding capacity between 1.0 and 1.5 inches. This amount of moisture is not adequate for survival of bare-root Douglas-fir in clearcuts on southerly and westerly aspects. On northerly and easterly aspects, cold soil and air temperatures and the subsequent short growing season combine with the low moisture holding capacity and low fertility normally associated with these soils to substantially hinder reforestation efforts. Clearcutting is not recommended on Yellowstone soils and it is recommended that partial cutting not exceed 40 percent of the stand.

When Yellowstone soils occur in association with 40 percent or more rock outcrops, they should be considered fragile, noncommercial sites and withdrawn from the commercial timber base.

The physiographic position where the Yellowstone soils are most unstable is the drainage headwall. It is characteristically very steep and ground water tends to rise very rapidly during intense storms creating a bouyancy force which can lift the soil free of the slope. The finite balance which exists in headwall positions is frequently upset by road construction and clearcut logging. A sufficient live residual root network must remain following the harvest of timber if massive slope failures are to be avoided in the headwall regions dominated by Yellowstone soils. Removal of as

little as 38 percent of the stand on these areas has resulted in massive slope failures. Recommendations are to not harvest timber in the headwall regions.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient, ground water rise as related to precipitation, and tree root strength. Yellowstone soils are too shallow, too fragile, and too steep for either clearcutting or tractor logging. If timber must be harvested on Yellowstone soils then the following is recommended:

1. Require an "on-site" inspection by a soil scientist and geologist to determine slope stability.

2. Require a cable yarding system and full suspension of logs.

3. On southerly aspects: lop and scatter slash on site. Gross yard slash out of headwalls and steep V-shaped drainages to landings using cable system and full suspension.

On northerly aspects: Gross yard slash to landings using cable system and full suspension.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures, residue left provides dead shade and benefits establishment of natural or planted seedlings.

All burning to reduce residues will result in losses of nitrogen, boron, sulfur, and phosphorous from the site. Burning tends to decrease wettability of soils usually in proportion to the intensity of the burn. Hot fires through the destruction of surface organic layers will have a significant impact on nutrient capital and availability. They will also reduce the infiltration capacity; and increase susceptibility to surface erosion and subsequent stream sedimentation. The destruction of dense living residue will increase ground water temporarily by the amount of transpiration eliminated. This increase in combination with the destruction of root systems by a hot burn can substantially decrease slope stability and initiate mass wasting events.

Prescribed area or broadcast burning will cause surface erosion on south and west aspects of Yellowstone soils. Dry ravel during the summer months is significant. It is recommended not to burn southerly and westerly aspects of these soils.

Prescribed area or broadcast burning may be necessary on some sites on northerly aspects to facilitate regeneration and cultural operations. However, in order to avoid or mitigate the above described impacts, careful

site-specific planning, incorporating the recommendations of the District Soil Scientist and a fire management specialist, is necessary.

Machine piling of slash and/or scarification is not recommended due to the shallow depth, stoniness, and steep togography of Yellowstone soils. The subsequent burning of slash in piles will substantially intensify the impact normally associated with either wildfire or prescribed burning. The concentrating of slash in piles for burning is highly detrimental to the soil underlying the piles and is not recommended.

These soils contain low amounts of organic matter and nitrogen. Vegetation succession by species which either add nitrogen to the site or accumulate nutrients in large amounts should be encouraged.

The redistribution of nutrient capital through the displacement of soil organic and mineral matter and subsequent concentration of this material underneath the piled slash, adds substantially to the losses in forest productivity associated with this practice.

These soils are in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

Road construction requires mostly blasting. The material below the soil is usually hard basalt. Cut bank stability is high on slopes less than 80 percent and low on slopes over 80 percent. The most common failure is sidecast sluicing out.

Road construction can cause severe erosion on Yellowstone soils when they are on sideslopes over 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and especially in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Yellowstone soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slopes greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain

sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only with specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10%.

3. Do not drain roads into concave positions.

Yellowstone soils are poorly suited for helipond locations because they are porous and occur on steep slopes. They are poorly suited for material to construct small dams because of a low clay content and high stone content.

III. Summation of Soil Behavior and Mitigating Recommendations

I. Recommended extension of frequency of cutting cycles and length of rotations on all lithic and paralithic (less than 20" of soil depth), skeletal (greater than 35% coarse fragments as gravel or cobbles) soils. This applies basically to all soils supporting site Class V timber stands. (Jason, Witzel, Umpcoos, Kilchis, Winberry, and Yellowstone).

II. Recommended withdrawal of all lithic (<20" soil depth), skeletal (>35% co. frag.) soils which occur in association with 40% or more rock outcrop. (See above list of applicable soil series).

III. Harvesting

A. Clearcutting is not recommended on the southerly and westerly aspects of the Kilchis, Witzel, Atring, Ritner, and Jason series due to the severe reforestation problems and potential for reduction in site productivity through soil less and also for the protection of water quality.

B. Clearcutting is not recommended and partial cutting should not exceed 40% of the stand on all aspects of lithic, skeletal soils when in the cryic temperature regime. (Winberry, Yellowstone)

C. Clearcutting is not recommended on any aspect of the lithic, skeletal Umpcoos soils due to an overall lack of slope stability. An "on-site" inspection by a soil scientist and forester to determine the gross tree volume and average tree spacing necessary to maintain a slope stability factor of 1.1 or greater (Burroughs and Thomas, 1976) should proceed any planned harvest operations.

D. Clearcutting is recommended on all aspects of all other soils except for Mixed Alluvial Land and soils with aquic moisture regimes. (Dupee, Hazelair, Minniece, Panther, and Nestucca).

E. Recommendations are to not harvest any timber in the headwall regions of lithic, skeletal soils (Witzel, Umpcoos, Kilchis, Winberry, Yellowstone, and Jason). Removal of as little as 38% has resulted in mass wasting.

Harvesting of timber in the headwalls of all other soils on slopes exceeding 70 percent should involve an on-site inspection by the a soil scientist and geologist to determine requirements for maintenance of slope stability and potential site degradation. These types of soils are easily transformed into man-made rockland.

F. Harvesting on lithic, skeletal soils other than Umpcoos should require an on-site inspection by soil scientist and geologist to determine slope stability.

G. All lithic, skeletal soils have recommendations to:

- Use a cable yarding system with full suspension of logs.
- Lop and scatter slash on southerly aspects.
- Gross yard slash with full suspension on northerly aspects.
- Gross yard slash out of headwalls and steep U-shaped drainages to landings using full suspension.

(Witzel, Umpcoos, Kilchis, Winberry, Yellowstone, and Jason)

H. Recommendations for harvesting on all loamy-skeletal (coarse-textured) and moderately deep soils (Atring, Digger, Harrington, Jason, Unnamed 166, Klickitat, Holderman, and Hummington); example:

These soils are low in clay content. They do not compact as easily from tractor logging as the finer textured soils found on the District. However, they are susceptible to significant levels of compaction and significant reductions in the volume and height growth of Douglas-fir. Most of these soils occur on slopes too steep for tractor logging. High-lead cable yarding capable of achieving at least partial suspension of logs is recommended. On areas that have slopes less than 35%, these soils can safely be tractor logged provided the following precautions are followed:

1. Plan all primary skid trails prior to logging operation and restrict primary and secondary skid trails to less than 10 percent of the area. Maximize winching distances up to 100 feet and distances between trails up to 200 feet where feasible.

2. Require felling of trees to lead to the skid trails to reduce the ground the skidder or tractor covers.

3. Allow tractors or skidders to operate only when the soil moisture is 25 percent or less, usually from July 15th to October 1st on southerly aspects. Delaying of the actual felling of trees until these conditions are achieved will lengthen the operating period by allowing evapotranspiration processes of the tree canopy to contribute toward the achievement of these conditions. Premature interruption of evapotranspiration processes through early felling of trees may prevent the achievement of 25 percent soil moisture. Even with delayed felling, soil moisture may not reach 25 percent on northerly aspects of these soils, thus precluding the use of all yarding systems other than cable. It is recommended that soil moisture be checked in years preceding sale to determine if 25 percent can be achieved.

4. Rip all skid trails. Ripping should immediately follow logging operation and take place no later than October 1. Soil moisture conditions during this period would provide

for reasonably effective ripping operations and would facilitate early reforestation efforts. Ripping should be to a minimum depth of fifteen inches with ripped furrows no farther apart than eighteen inches, center to center.

When yarding is to be accomplished utilizing high-lead cable systems, it is recommended to:

1. Require complete suspension of lead end of logs during yarding.

2. Require gross yarding of slash with at least partial suspension. Lop and scatter finer residues.

Gross yarding leaves fine residues in place; maintains organic cover and soil microbiological activity; keeps major amount of nutrients on the site; enhances infiltration of moisture; reduces evaporation; and restricts detrimental effects of burning to landings - all factors that benefit tree growth as well as protect the soil resource. On south exposures residue left provides dead shade and benefits establishment of natural or plant seedlings.

I. Recommendations for harvesting on fine textured soils (Abiqua, Apt, Bellpine, Blachly, Bohannon, Cloquato, Cruiser, Cumley, Dixonville, Dupee, Hazelair, Hembre, Honeygrove, Jimbo, Jory, Keel, Kinney, Marty, McAlpin, McCully, Meda, Minniece, Mulkey, Nehalem, Nekia, Nestucca, Panther, Peavine, Philomath, Preacher, Ritner, Saturn, Sifton, Slickrock, Veneta, and Willakenzie) are essentially the same as for loamy-skeletal (coarse-textured) soils except for the following:

Soils high in clay content are highly susceptible to compaction from skidders or tractors. Soil compaction on these soils will signficantly reduce the volume and height growth of Douglas-fir. The reduction in growth will be generally proportional to the degree of compaction including the percent of the root zone affected. Compaction due to unmitigated, indiscriminate tractor logging will reduce merchantable volume in the following rotations about 13 percent.

Recommendations are to:

1. Require a cable yarding system and at least partial suspension of logs or use low ground-pressure tractors which exert six pounds per square inch or less on the soil and which suspend lead end of logs.

2. Permit rubber-tired skidders only on permanent roads.

J. Recommendations are to not harvest on Mixed Alluvial Land (Floodplains).

K. Recommendations are to not harvest on soils with an aquic moisture regime due to reforestation problems. (Dupee, Hazelair, Minniece, Panther and Nestucca).

IV. Burning

A. Recommendations are to not burn slash on southerly and westerly aspects of all loamy-skeletal (coarse-textured) soils where slope gradients exceed 75 percent.

B. Recommendations for all other situations were to restrict burning to landings if possible, but otherwise recommended careful site specific planning on broadcast burns. (This is where spring burns and moisture conditions would come to play).

V. Machine piling of slash and brush and/or scarification as well as subsequent burning of slash in piles is "significantly" if not "highly" detrimental to long term productivity. Machine piling is not recommended on any soil. However, if it is determined that satisfactory alternatives do not exist for a specific site, and that machine piling and burning is necessary to facilitate reforestation then the following mitigating measures are recommended:

1. Cable yarding of merchantable timber with intensive gross yarding to reduce the number of trips needed to pile the remaining debris. Piling should be on the contour; constructing the piles uphill to reduce soil displacement.

2. Strict enforcement of soil moisture restrictions on tractor piling activities.

3. Strict enforcement of the type of brush blade used. An extra allowance may be needed for purchase or rental of a good brush blade.

4. Strip clearing and wind-rowing rather than 100 percent clearing and large brush piles. Large material that did not meet gross yarding requirements (short, large-diameter chunks) should be excluded from the piles.

5. Do not allow tractors to make repeated trips or pile in areas within the sale area that do not require such action.

6. Burning of wind-rows during periods of high soil moisture.

7. Ripping the soil with an adequate ripper attachment (extra appraisal allowance again) during summer-dry soil conditions, with a contract administrator on the site during the operations.

These mitigating measures do not apply to either shallow soils or soils which have aquic moisture regimes. Machine piling and burning should not occur on these soils under any circumstances.

VI. Road Construction

A. For road construction on well drained, fine-textured soils (Abiqua, Apt, Bellpine, Blachly, Bohannon, Cloquato, Cruiser, Cumley, Dixonville, Dupee, Hazelair, Hembre, Honeygrove, Jimbo, Jory, Keel, Kinney, Marty, McAlpin, McCully, Meda, Minniece, Mulkey, Nehalem, Nekia, Nestucca, Panther, Peavine, Philomath, Preacher, Ritner, Saturn, Sifton, Slickrock, Veneta and Willakenzie); the following is recommended:

Road construction is generally easy in these soils. Crawler tractors equipped with a blade and a ripping attachment are usually adequate for excavation. The material below the soil is usually deeply weathered or highly fractured.

These soils commonly occur on gentle ridge tops or old landslide topography that has benches and short steep slopes. Frequently the benches are remnants of rotational slumps. The most unstable areas associated with these soils are the steep, concave slopes at the heads of drainages, the edges of benches, or those areas where ground water accumulates. The most common slope failures are of the slump and earthflow type. Road failures frequently involve poorly consolidated or poorly drained road fills and embankments greater than 12 to 15 feet high. Road locations through this kind of landscape must be done with care. The most stable location for a road that has to go near a rotational slump is on the top and toward the inside edge near the bottom of the upper scarp but not undercutting it in anyway. This prevents excavation into the toe of the slump which would reduce its support. If a road must be built through the toe of a rotational slump it must be designed by a civil engineer and/or engineering geologist in order to incorporate the necessary retaining structures and drainage measures.

Slope stability is a complex interaction of soil sheer strength, soil depth, slope gradient and ground water rise It is recommended not to drain roads into the edges of benches or concave slopes as this can upset the finite balance essential to the stability of these positions.

Sidecast from soils on slopes less than 50% is normally stable. Both cutbanks and sidecast respond well to seeding and mulching. Fill embankment and subgrades should be compacted to accepted engineering standards, paying special attention to equipment, proper lift thickness, moisture content, and foundation conditions. If ground water is present, then the installation of perforated pipe encased in crushed rock filters or a blanket of crushed rock under the entire fill should be considered. Cutbank heights in excess of 12 to 15 feet should be avoided. Cutbank stability is moderate on slopes less than 35% and low on slopes over 35%.

Sediment from road construction in these soils will be fine textured and easily suspended in runoff water. Special consideration must be given in the design and construction of roads to prevent subsequent sediment from entering any riparian zones or streams. Recommendations are to:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.
2. Establish rock and/or vegetative that covers at least 75% of all bare surfaces (e.g. roadbed, cut embankments, and slopes).
3. Install half rounds with energy dissipators on all culverts discharging on embankments and slopes with grades in excess of 10%.

Rocking roads in soils is necessary for winter hauling. Either rocking or seeding, mulching, and blocking off temporary spurs is recommended.

Soil Behavior and Recommendations (fine textured soils over tuffs and breccias):

All the above statements for fine textured soils over sedimentary rock apply to fine textured soils over tuffs and breccias with the following exceptions:

1. Soils over tuffs and breccias contain more expanding type clays. Sediment coming from disturbed areas tends to stay in suspension longer. Recommendations is to rock all roads.
2. Cut slopes and fill embankments have a higher incidence of failure.
3. Extra road rock is needed on new fills made from these soils. Experience has shown that 16 to 24 inches of rock is needed to hold up log trucks.

Soil Behavior and Recommendations (fine textured soils over basalt, gabbro, and diorite):

All of the above statements for fine textured soils over sedimentary rock apply to fine textured soils over basalt, gabbro, and diorite with the following exceptions:

1. Soils and underlying bedrock are more stable and subsequently the environmental risk from road construction failures is much less.

2. The hazard of sediment from roads, reaching streams is much less.

3. Road construction costs will be much higher as considerably more ripping and blasting will be required.

B. For road construction on loamy-skeletal (Atring, Digger, Harrington, Holderman, Hummington, Jason, Kilchis, Klickitat, Umpcoos, Unnamed 166, Winberry, Witzel and Yellowstone) soils irrespective of depth; the following is recommended:

Road construction requires mostly blasting. The material below the soil is usually hard basalt. Cut bank stability is high on slopes less than 80 percent or in draws with slopes over 75 percent. When sidecast becomes saturated it overloads the soil below it and triggers large debris avalanches.

In very steep physiographic positions and especially in headwall positions; road construction is not recommended. However, if roads must be built through these critical positions and on Witzel soils in general, then the following is recommended:

1. Roll the grade and maximize avoidance of headwalls; slope greater than 80 percent; and other unstable areas.

2. Use controlled blasting techniques (e.g. pre-splitting and shooting with minimum loading using delays) to minimize overbreak of rock material and maximize containment of material on-site.

3. Where sufficient timber is present in the planned right-of-way it should be felled from the designed grade upwards to the clearing limit on contour with the slope. The felled timber will then retain sidecast generated from the initial cut allowing it to be brought into the roadway as the road is brought down to finished grade.

4. Excavate only the specialized equipment such as a "overshot" loader, power shovel, or small tractor (e.g. D-5) equipped with U-shaped blade and scrapers.

5. Endhaul all excavated material. Selection of disposal sites requires as much care as does the location and construction of the road.

Consideration must be given in the design and construction of roads to prevent sediment from these roads from entering riparian zones or streams. Recommendations are:

1. Offset the low point in the road and install crossdrains, dips, ditch relief culverts, and berms in a manner that allows runoff to filter through natural vegetation before entering a stream or riparian zone.

2. Install half rounds with energy dissipators on all culverts discharging on fill embankments and fill slopes with grades in excess of 10 percent.

3. Do not drain roads into concave positions, e.g. headwalls.

VII. Herbicide Use:

A. Lithic, loamy-skeletal soils (Witzel, Umpcoos, Kilchis, Winberry, and Yellowstone):

These soils are low in clay minerals, somewhat excessively drained, and shallow to moderately deep over impermeable bedrock. These characteristics are indicative of a low ability to adsorb and retain on site, those herbicides which are relatively mobile with respect to soluability and adsorptive or absorptive properties.

B. Aquic moisture regimes, poorly drained (Dupee, Hazelair, Minniece, Panther, and Nestucca):

Application of herbicides as a silvicultural prescription for controlling competing vegetation is not recommended on these soils. The topographic position and soil moisture conditions gives these soils an intrinsically high hazard with respect to the translocation of herbicides to ground or surface water.

IV. Additional Soil Characteristics and Ratings

A. Soil Genetic and Physical Properties

1. Climate

The climate of the area differs in total precipitation, average annual temperature and amount of solar radiation. These climatic factors influence soil formation and development through their effect on rates and types of chemical weathering and the native vegetation.

The climate of the area produces precipitation levels which exceed evapotranspiration rates and soil moisture holding capacities, so that an excess of moisture accumulates and flows to the ocean. This excess moisture enhances chemical weathering with sufficient leaching of the soils to carry away the soluable products of the weathering processes. The basic constituents of the parent Tyee sandstone and intrusive rocks of the area are removed leaving the oxides of iron, aluminum and silicon and the inert mineral quartz.

The late spring and early summer period is warm and moist which favors the oxidation of the soluble form of iron to the insolube form which remains in the soil while the oxides of aluminum and silicon eventually leach away. This process of soil development produces soils which are red, such as the Jory and Honeygrove soils.

The climatic condition of the area favors leaching of the basic constituents and soluble bases particularly from the surface soil which allows the clay minerals to disperse. The downward migration of clay from the surface soil (zone of eluviation) or percolating water is arrested in the subsoil zone by the removal of water by plant roots, leaving the clay stranded in the subsoil (zone of illuviation). This clay enrichment in the subsoil, if of sufficient amounts, qualifies as an argillic horizon. Jory and Honeygrove soils are examples of soils having argillic horizons in the area.

The leaching process also determines to a large extent the chemical base status of soils. Digger soils have a high base saturation, possibly suggesting that leaching is not effective while Bohannon and Jason soils, on the other hand, have a low base saturation, suggesting an effective leaching condition. Soil studies in the Coast Range, substantiated with laboratory analysis of soil samples taken on the Nelson Ridge System in T. 17 S., R. 7 W., Will. Mer., indicate the downslope movement of base-rich ground water increases the base saturation of soils that are on lower slopes as compared with soils upslope.

Soil temperatures control the rate of many processes, including the activity of organisms involved in the breakdown of organic matter, as well as plant growth, water absorption and soil

formation. Biological processes in the soil, controlled largely by soil temperature and moisture, do not become active until soil temperatures exceed 42°F to 45°F. Mean air temperatures are closely related. Usually, the mean soil temperature is about 2°F warmer than the mean air temperature.

Soils of the Eugene District fall within the different soil temperature regimes. The soil temperature regimes are the "Cryic" and "Mesic" regimes. Cryic soils are simply these soils with mean annual soil temperatures less than 47°F and Mesic soils are those with mean annual soil temperatures greater than 47°F. The soil moisture regimes are the "Xeric" and "Udic" regimes. Xeric soils are dry 45 consecutive days during the summer and fall months and moist for 45 consecutive days during the winter and spring months for at least 6 out of 10 years. Xeric sites are characteristized by vegetation consisting of Douglas-fir, Oregon white oak, Madrone, Incense-cedar, Chinquapin and an understory of poison oak, ocean spray, manzanita, salal, and hazel. Oregon white oak and madrone are considered most indicative of the Xeric zone. Udic soils are not dry for 45 consecutive days during the summer and fall months for at least 6 out of 10 years. Udic soils in the Mesic zone are typified by vegetation consisting of Douglas-fir, Western redcedar, Grand fir, vine maple, red alder, red huckleberry, sword fern, bigleaf maple, and oxalis. Red huckleberry and sword fern are considered most indicative of Udic soils in the Mesic zone. Udic soils in the Cryic zone are typified by vegetation consisting of Douglas-fir, Western redcedar, Western hemlock, silver fir, Western white pine, blue huckleberry and beargrass. Silver fir, Western white pine and beargrass are considered most indicative of Udic soils in the Cryic zone.

2. Parent Material

The parent material of a soil refers to the unconsolidated material in which the soil developed. The majority of the parent materials in the area are unconsolidated superficial deposits of colluvial origin rather than the residual bedrock. The parent materials were weathered from arkosic sandstone and shales of the Tyee formation; extrusive igneous rocks (basalts) and intrusive igneous gabbros and dioritic rocks.

The nature of parent material depends on the mineralogy of the parent rock, and the degree to which the rock has been weathered and transported. Weathering and transportation are related to geologic structures, climate, and such geologic events as uplift, faulting, erosion, and deposition.

The adjective "arkosic" used to describe the sandstone rock of the Tyee formation indicates that the presence of more than 25 percent of the mineral constituents are feldspars. This sandstone is also micaceous because it has abundant wrinkled

flakes of muscovite and biotite. These materials yield a host of weathering products, but the availability and supply of phosphorus from these rocks, as best determined by present laboratory techniques, is low, although sufficiently stable for plant growth.

The intrusive rocks, largely gabbro, generally contain over 50 percent feldspar minerals. These rocks weather more slowly than the clastic sandstone rocks of the Tyee formation and generally have a higher base status. Soils derived from weathering of these rocks, when on steep slopes, are predominately stony, shallow; having a low moisture supplying capacity, and low natural fertility. Soils developing on gentle, stable slopes are predominately deep, loamy and non-stony with an abundant supply of nutrient elements essential for plant growth. Although they have a lower level of potassium available than soils occurring over Tyee sandstone the level is stable enough for plant growth. Hembre soils are an example.

3. Age

Differentiation of the soil profile into horizons reflect the relative age of the soil. Young soils generally show little if any modification of the parent materials and occur in deposits of recent alluvium in stream bottoms and on steep mountainous uplands in recent colluvial materials or where geologic erosion has proceeded at a rate equal to the rate of soil development. The soils in the bottom lands are generally unconsolidated silt loams, loams and loamy sands that are nearly level to gently sloping. Many of these soils are as young as 455 to 655 years. The shallow soils on steep slopes are gravelly loams, gravelly silt loams and gravelly silty clay loams.

The oldest soils in the area like the Jory and Honeygrove soils have deep, well developed profiles in which the horizons are clearly differentiated from one another. Usually the surface soil is characterized by at least two well defined horizons of similar texture but different in color. They are designated as A1 or A3 horizons. Immediately beneath the A horizons is found the subsoil or zone of accumulation which contains more clay than the surface soil. The weathering processes have proceeded far enough to differentiate the subsoil into two or more horizons of different colors as a result of different degrees of oxidation of the material. Soil structural units, or peds, are generally strongly developed in the older soils, also.

Honeygrove soils that occur on stable ridges in the Coast Range are at least 9,570 years old. Local differences in soil age and development are expected where landscapes are relatively unstable, as in much of the inventory area.

4. Topography

Topography refers to the steepness, length and regularity of slope. The steepness of slope is the factor of topography that has the greatest bearing upon soil development. It operatres through its influence on the rate of erosion and drainage. A steep topography favors a high rate of erosion and drainage. A high rate of erosion tends to remove the products of rock weathering so that steep soils tend to be shallow and skeletal such as Jason and Kilchis soils. Also a high rate of erosion prevents the complete development of the soil profile. So generally speaking, old soils are not found on steep topography, but develop on broad, relatively stable slopes. These stable surfaces have been subjected to less erosional losses, and are commonly more deeply leached and strongly developed.

In addition to slope steepness, the shape of slope influences soil development through its effect on the hydrologic conditions at different positions in the landscape. For example, there is a greater net loss of precipitation due to runoff, from the steeper convex slope, than on concave slopes where runoff is slower and water tends to accumulate.

5. Soil Depth

The depth to bedrock has a significant impact on rooting depth, nutrient capital, available water holding and supplying capacities, and on road construction. The soil depth classes are defined as follows:

Class	Depth in Inches
Deep	>40
Moderately Deep	20 to 40
Shallow	<20

The most significant break in soil depth class with respect to productivity and construction activities is at 20 inches. Soils having 20 inches or less depth to bedrock are referred to as "Lithic" or "Paralithic" soils. These are important terms, in that, the term "Lithic" roughly correlates to non-rippable materials and "Paralithic" to rippable, partially weathered materials. The term "Lithic" is always indicative of a definite limit to the effective rooting zone but the term paralithic, depending on the parent rock and degree of weathering, may or may not indicate as definite or severe of a restriction on productivity.

6. Available Water Holding Capacity

Available water holding capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the

difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants. It depends largely on effective rooting depth, texture, organic matter content and coarse fragment content. In general, profiles that contain 50 percent coarse fragments by volume will have only one-half the moisture holding capacity of a comparable soil that is free of coarse fragments. The following five classes are recognized:

Class	Available Water in Inches
Very High	More than 12
High	9 to 12
Moderate	6 to 9
Low	3 to 6
Very Low	Less than 3

7. Water Supplying Capacity

The water supplying capacity is the sum of the available water holding capacity and the precipitation received during the growing season, expressed in inches for the total soil profile. The available water holding capacity is filled at the beginning of the growing season in this region. When plant growth begins, evapotranspiration losses of water reduce the available soil moisture content. Consequently, any rains received during the growing season will add to the available soil moisture content and become part of the water supplying capacity.

The water supplying capacity data helps explain why timber production is better on the udic soils than on the xeric soils, and better on the deep soils than on the moderately deep and shallow soils. The moderately deep xeric Bellpine soils, for example, have an average water supplying capacity of about 17 inches while the deep udic Honeygrove soils have an average water supplying capacity of 24 inches. The site index for Douglas-fir is about 140 on the Bellpine soils, and about 165 on the Honeygrove soils.

8. Reaction Range

Soil reaction is the degree of acidity or alkalinity of a soil expressed in pH values. Soil reaction classes are defined as follows:

Class	pH Range
Extremely acid	Below 4.5
Very strongly acid	4.5 - 5.0
Strongly acid	5.1 - 5.5
Medium acid	5.6 - 6.0
Slightly acid	6.1 - 6.5
Neutral	6.6 - 7.3

9. Soil Drainage

Soil drainage refers to the rapidity and extent that water is removed from the soil and to the periods when the soil is free of conditions of saturation or partial saturation.

Well drained soils are characterized by free areation and oxidizing conditions, but soils with restricted drainage may become stagnant because micro-organisms and plant roots use the dissolved oxygen faster than it can be renewed. This anaerobic condition leads to the chemical reduction of iron and its mobilization in solution. Iron is thereby lost from parts of the soil which then become drab grey in color and may be concentrated in other parts of the soil as a rusty color. These patches of color are termed mottles and their presence or absence are an invaluable tool for field determination of drainage conditions even though the soil profile may be dry at the time of inspection.

These processes, which are collectively referred to as gleying, vary throughout the year depending on the moisture status of the soil. Although precipitation exceeds evapotranspiration for most of the year, the soils in the inventory area which are affected by gleying are the exception rather than the rule. Soils which exhibit intense gleying occur only as minor inclusions within soil mapping unit delineations and are a result of micro-site conditions.

Seven class of drainage are described below on the basis of observations and inferences used to obtained classes of runoff, soil permeability and internal soil drainage.

Very poorly drained: Water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time.

Poorly drained: Water is removed so slowly that the soil remains wet for a large part of the time. The water table is commonly at or near the surface during a considerable part of the year.

Somewhat poorly drained: Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time.

Moderately well drained: Water is removed from the soil somewhat slowly, so that the profile is wet for a small, but significant part of the time.

Well drained: Water is removed from the soil readily, but not rapidly.

Somewhat excessively drained: Water is removed from the soil rapidly.

Excessively drained: Water is removed from the soil very rapidly.

10. Permeability

Soil permeability is that quality of soil that enables it to transmit water and air. It is measured in terms of rate of movement of water through a unit cross-section of saturated soil per unit of time. In the absence of precise measurements, the soils are placed into relative permeability classes through studies of structure, texture, bulk density, porosity, and other characteristics of the horizons in the soil profile. Permeability for the whole soil is determined by the least permeable layer.

11. Surface Runoff

Surface runoff, or overland flow of water results when the precipitation rate exceeds the infiltration rate of the soil. The infiltration rate for a particular soil varies with the antecedent moisture content and the structure and porosity of the surface layer. It is relatively high for soils that are dry at the beginning of a rain storm and reaches a minimal steady state in a soil that is nearly saturated; that is equal to the permeability rate of the least permeable horizon in a soil. An undisturbed soil with a cover of litter generally has a higher infiltration rate than a bare soil. The infiltration rate is also inversley related to the degree of compaction. Surface runoff is the cause of sheet, rill, and gully erosion. Surface runoff is not common on most of the soils in the Eugene District under natural vegetative cover even in fairly intense storms. This is due to the fact that: (1) the soils are quite porous and permeable; (2) violent or intense rain storms for prolonged durations are uncommon and (3) density of intercepting layers of natural vegetative cover. Table 2 presents data that illustrates the relationship between permeability rates (which control infiltration rates for saturated soils), precipitation rates for storms of selected durations and frequencies and the expected runoff rates for these storms.

Median values are presented in Table 2 for both the permeability rates and the precipitation rates. It should be recognized that the permeability rate of each soil series covers a range of values instaed of a finite figure. Also, it should be emphasized that any one soil series occurs in a zone that covers a range of rainfall conditions instead of one specific value. Nevertheless the data in Table 2 substantiates the observation that surface runoff on undisturbed soils is uncommon. In the xeric zone, Bellpine soils, which have a slow permeability, can be expected

to produce about one inch of runoff from the maximum 6-hour storm that occurs once every 25 years. In the udic zone, the fine textured Honeygrove and McCully soils can be expected to produce one-half inch or more runoff for the same kind of storm. The data in Table 2 assumes the soil is nearly saturated at the start of the storm. If the water holding capacity was depleted an inch or more when the storm began, none of the soils would produce any significant runoff.

Road construction, logging operations, and broadcast burning commonly increase surface runoff. Generally the finer the soil texture, the greater is the affect of these activities on increasing runoff or reducing infiltration. The skeletal or very gravelly soils are the least affected. The surface runoff ratings given in Table 2 are for soils that are under natural vegetative cover.

Some of the soils have been observed to have increased runoff after broadcast burning because they temporarily become water repellant. It has been observed for the Jason and Digger soils (loamy-skeletal) especially, that hot broadcast burns create non-wettable surface layers that repel moisture absorption. This is thought to be attributable to the removal of surface organic debris, removal of organic matter in the soil and the breakdown of water-stable soil aggregates.

B. Productivity for Douglas-fir

Soil productivity is the capacity of a soil to produce a particular yield of a specific plant in a given climate and under a defined level of management. Soil productivity is a function of its physical and chemical nature. Productive soils have good tilth (physical condition) and good fertility (chemical condition). Some fertile soils have low productivity for Douglas-fir because of adverse physical characteristics such as depth of soil, solum, or surface horizon; high coarse-fragment content; or adverse soil temperature or moisture conditions.

The productivity or capacity of the soils to produce wood are rated in terms of estimated site index values for Douglas-fir growing under natural conditions. Site index relates tree height with age and the defined values given in USDA Bulletin No. 201, where the trees height at 100 years of age, is used. The estimates are based on field measurements made on representative sites of the soil series.

Site classes are defined in terms of ranges in site index values. The site classes are defined as follows:

Site Class	Site Index Values (feet)
I	186+
II	155 - 185
III	125 - 155
IV	95 - 125
V	Below 95

Site index values and site classes are assigned to each soil series in the soil behavior narratives under Part IV of this handbook and are also given in Table 3.

C. Regeneration Limitations for Douglas-fir

Regeneration refers to the re-establishment of a desired tree species to a satisfactory rate of stocking, within an acceptable time frame after harvesting; and in a manner that maintains long term productivity and environmental quality. The soils are rated in Table 4 on the basis of relative chances for success of regeneration of a juvenile forest by planting 2-0 bare root seedlings.

Regeneration success is a function of soil, climate and topographic features which affect water supplying capacity, evapotranspiration and erosion and mass movement. Generally deep, non-skeletal soils on gentle or moderate north facing slopes in the Udic moisture zone have the least hazard for regeneration. Shallow, skeletal soils on south facing, very steep slopes, especially in the Xeric zone, have the most severe hazard for regeneration.

The three classes of regeneration hazard used in Table 4 are defined as follows:

Slight: The soils have either: (1) a high moisture supplying capacity, and occur in the Udic moisture regime on both north and south facing slopes that are generally less than 60 percent; or (2) they have a moderately high moisture supplying capacity and occur in the Udic moisture regime on north facing slopes that are generally less than 80 percent.

Moderate: The soils have either: (1) a moderately high or high moisture supplying capacity and occur in the Xeric moisture regime on north facing slopes that are generally less than 60 percent; or (2) they have moderate moisture supplying capacity and occur in the Udic moisture regime on north facing slopes that are generally less than 80 percent.

Severe: The soils have either: (1) a moderately or moderately high moisture supplying capacity and occur on south facing slopes in the Xeric moisture regime; or (2) have a low moisture supplying capacity and occur in the Xeric zone on both north and south facing slopes that are generally very steep; or (3) have a low moisture supplying capacity and occur on south facing slopes in the Udic moisture zone that are steeper than 80 percent.

D. Soil Compaction Hazard

Soil compaction is more severe in some soils than others under the same amount of applied pressure. It is most severe in clayey soils, having no rock fragments; that are massive or weakly aggregated; have a high moisture content; and are low in organic matter.

Compaction has not been identified as a significant factor under cable yarding conditions but it has been identified as a problem of major significance to long term productivity, under tractor yarding conditions. Studies and observations by Minore (1967); Youngberg (1959); Chalfant and Amrhein (1978); Power (1974); Froehlich (1978); Dyrness (1965); Steinbrenner (1955); Minore (1969); etc., have demonstrated that compaction from unmitigated, indiscriminate tractor logging will reduce merchantable volume in following rotations about 13 percent. Recovery of this lost productivity by ripping under the most ideal conditions will be 60 percent or less; thus resulting in a loss of at least five percent even after ripping is applied. Dyrness (1965) found that tractor logging compacted approximately three times more area than did high-lead logging. Stinbrenner and Gessel (1955) found 26 percent of a logged area occupied by tractor skidroads. Youngberg (1959) discovered that the height growth of planted Douglas-fir seedlings on two plantations in tractor roads averaged 43 percent less in two growing seasons than those in undisturbed cutover. Chalfant and Amrhein found a loss of 57% under similar conditions. Power (1974) documented a situation where compaction resulted in a 40 percent reduction in yield at the stand age of 80 years.

The potentital loss in productivity due to compaction is magnified by the fact that nearly all of the acreage on the Eugene District, that has slopes favorable for tractor yarding; also has soils with medium to high compaction hazards. This becomes even more significant when one considers that the soils on these gentler slopes with high and medium compaction hazards, are also among the most productive (site Class II) forest soils on the Eugene District.

The soils covered in this handbook are rated slight, moderate, or severe according to the following criteria:

Slight: Soil properties generally remain favorable for a sustained level of production under most conditions of compactive effort. Most of these soils have a loamy-skeletal family textural classification.

Moderate: Porosity is reduced and bulk density is increased to the extent that production is somewhat lowered under most conditions of compactive effort. Special methods should be utilized to reduce the compaction impacts. Most of these soils have a fine-loamy family textural classification.

Severe: Porosity is reduced and bulk density is increased to the extent that site quality is significantly reduced and surface runoff is increased. These soils should not be subjected to compaction activities when they are moist. Most of these soils have a fine or clayey family textural classification. These ratings are found in Table 4.

E. Mass Movement Hazard

The two major kinds of mass movement of soils in the District are slumps and debris avalanches. Slumps are one or more blocks of soil that have rotated out of a hillside along a bowl-shaped failure plane. Debris avalanches are the rapid movement of incoherent soil, rocks, and forest debris down steep draws.

Slumps occur where there is an accumulation of water and the soils are often saturated with water. The potential for triggering a slump along a proposed road can often be identified by the presence of jackstrawed trees, sag ponds, water-loving vegetation, or tension cracks (Burroughs, et. al., 1973).

Slumps can be stabilized by: (a) removing weight from the upper part of the block; (b) rip rapping the toe of the block; (c) draining with horizontal drains and/or (d) surface draining to remove or divert water from the sag pond area.

Debris avalanches tend to occur in draws where the slopes are steeper than 65 percent, and the soils are shallow or moderately deep. Many debris avalanches are activated by man when he places sidecast

materials in the draws during road construction. The avalanche generally occurs in the winter wet season after the overloaded soil becomes saturated.

Debris avalanches occur mostly in the areas underlain by Tyee sandstone, hard tuffs and breccias. However, any headwall that is over 70 to 80 percent with a road built across it is suspect.

Local experience has shown that rolling the grade, using a minimum width road, and end hauling have substantially reduced debris flows. Particular attention needs to be given to the way the pioneer road is constructed. A method needs to be used that prevents large amounts of sidecast from being produced from the pioneer road. One technique of accomplishing this is the use of U-shaped blade on a small tractor (D6 size).

Front end loaders and dump trucks are the most common way of taking the road down to grade. Finding a disposal site for waste material is a difficult problem in steep terrain with sharp ridges. Selection of disposal sites requires as much care as does the location and construction of the road.

Some of the waste material can be placed in narrow saddles. Local experiences has shown that the material can be made stable by first excavating narrow bench roads just below the saddle and on either side. Waste material can then be placed on these benches and compacted. By doing this, fills as high as 10 feet can be placed in saddles no wider than 15 feet.

F. Engineering Interpretations

Table 5 lists various engineering interpretations for the soils mapped. It lists limitations ratings for some uses and suitability ratings for other uses and identifies those specific soil features or characteristics that can affect selection, design, or application of treatment measures. These listings are based on the estimated engineering properties given in Table 5 and field experience.

The interpretations are given as relative ratings such as slight, moderate, severe, and good, fair, or poor. These ratings will be defined within the respective definition, which follows on each item in the table heading:

1. Soil Suitability as a Source of Road Fill. The soils are rated according to suitability as a source of road fill. The ratings, good, fair, poor reflect how well a soil performs after it is excavated and used in an embankment elsewhere. Soils rated good for road fill materials have an AASHO classification of A-1, A-2, or A-3. those rated fair have AASHO classification of A-4 or A-5. The poor rating is for soils with an AASHO classification of A-6 or A-7.

2. Pond Location. Evaluating criteria for locating a pond on a particular site depends upon those features and qualities of undisturbed soils that affect their suitability for water impoundment. Of primary concern are soil properties that affect the seepage rate.

   The limitations ratings are as follows:

   Slight: A soil has a slight limitation if it has all the following features: Slopes less than 12 percent; permeability of less than 0.63 inches/hour; depth to bedrock over 60 inches; unified classification is GC, SC, CL, CH; organic matter is less than two percent.

   Moderate: A soil that has a moderate limitation has one or more of the following features: Slopes ranging between 12 and 30 percent; permeability between 0.63 and 2.0 inches/hour; depth to bedrock between 40 to 60 inches; unified classification GM, ML, SM, and MH; organic matter ranging between two and 15 percent.

   Severe: A soil has a severe limitation in it has one or more of the following: Slopes over 30 percent; permeability rate of two inches and greater; depth to bedrock is less than 40 inches; unified classification is GP, GN, SP, or SW, organic matter content is greater than 15 percent.

3. Embankments. Earthfill constructed to improved water. Three limitation ratings are used to reflect the major behavior qualities that affect, especially adversely, a soils performance as a compacted embankment.

   The limitation ratings are as follows:

   Slight: A soil has a slight limitation if it has all the following features: Unified classification of GC, SC, CL or CH; organic matter content less than two percent; a low shrink-swell potential; no coarse fragements larger than six inches in diameter.

   Moderate: A soil that has a moderate limitation for embankment material has one or more of the following features: Unified classification of GM, ML, SM or MH. Two to 15 percent organic matter; moderate shrink-swell potential; less than five percent large stones.

   Severe: A soil has a severe limitation for embankment material if it has one or more of the following: Unified classification of GP, SW, or SP; over 15 percent organic material; a high shrink-swell potential; over five percent large stones.

The remaining engineering interpretations shown on Table 5 are defined as follows:

1. Depth to Bedrock: The distance from the surface of the soil to the upper surface of the rock layer.

2. Depth to Seasonally High Water Table: The distance from the surface of the soil to where soil mottling indicators establish the presence of a water table.

3. Hydrologic Group: Soils are placed in hydrologic groups according to their potential to yield run-off. This information is used in watershed planning. Various hydrologic groups range from (a) that shed almost no precipitation to (d) that shed nearly all the precipitation.

The four hydrologic groups are defined as follows:

Group A. Soils having a high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well to excessively drained sands and/or gravel. These soils have a high rate of water transmission and would result in a low runoff potential.

Group B. Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C. Soils have slow infiltration rates when thoroughly wetted, consisting chiefly of (1) moderately deep soils with a layer that impedes the downward movement of water, (2) soils with moderately fine to fine texture and a slow infiltration rate, (3) soils with moderate water tables (these soils may be somewhat poorly drained); or (4) deep clay soils. These soils have a slow rate of water transmission.

Group D. Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) clay soils with a high swelling potential; (2) soils with a high permanent water table; (3) soils with a clay pan or clay layer at or near the surface; and (4) shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

4. Depth from Surface to Typical Profile: the depth from the surface of the major horizons that are subsequently described in the columns that follow.

5. Classification: The USDA textural; the Unified; and the American State Highway Officials (AASHO) engineering classifications.

6. Coarse Fraction Greater than Three Inches: This column lists percentages by weight, of the coarse fractions in the soil profile.

7. Liquid Limit: The moisture content at which a soil passes from a plastic to a liquid state. The value of this test is that it

indicates at which moisture content a soil overcomes internal friction and cohesion by lubrication.

8. Plasticity Index: This is the numerical difference between a soils plastic limit and liquid limit. Soils having high PI values have a high degree of cohesion. A soil with a zero PI is cohesionless or non-plastic.

9. Maximum Dry Density: The highest dry density obtainable by a defined compactive effort (test).

10. Optimum Moisture Content: The moisture content at which a given compactive effort yields the maximum dry density.

11. Shrink-Swell Potential: That quality of the soil that determines its volume change with changes in moisture content. Building foundations, roads, and other stuctures may be severely damaged by the shrinking and swelling of the soil. The volume change of soil is influenced by the amount of moisture change and the amount and kind of clay.

Three classes are defined below which rate a soil's shrink-swell potential.

Low: Soils which have a low shrink-swell potential have the following: Unified classification - SP, SM, GP, and possibly ML; soil textures of loamy sand, sand, silt loam, silty clay loam, clay loam, silty clay, sandy clay, and clay that contains Kaolinite or other low shrink-swell clay minerals; a COLE less than 0.03.

Moderate: Soils which have a moderate shrink-swell potential have the following: Textures that are silty clay, silty clay loam, clay loam, sandy clay loam, and clay containing mixed clay minerals that include some montmorillinite or other high shrink-swell minerals; a COLE of 0.03 to 0.06.

High: Soils which have a high shrink-swell potential have the following: Textures that are clay loam, silty clay loam, silty clay, sandy clay and clay that are made up of a large percentage of montmorillinite or other high shrink-swell minerals; a COLE of more than 0.09.

VI Appendix

A. Index to Soil Series by Mapping Unit Symbol

Soil Identification Legend
Lane County Area, Oregon
June 21, 1979

Map Symbols	Mapping Unit Name
80A	Abiqua silty clay loam, 0 to 3 percent slopes
81B	Abiqua silty clay loam, 3 to 5 percent slopes
546S	Astoria silt loam, 5 to 30 percent slopes*
496K	Atring-Rock outcrop complex, 30 to 60 percent slopes*
280A	Awbrig silty clay loam
280AU	Awbrig-Urban land complex
214B	Bandon sandy loam, 0 to 7 percent slopes
215C	Bandon sandy loam, 7 to 12 percent slopes
216D, 217H	Bandon sandy loam, 12 to 50 percent slopes
60A, 61A	Bashaw clay
60AU	Bashaw-Urban land complex
480B, 635C	Bellpine silty clay loam, 3 to 12 percent slopes
481C, 636D	Bellpine silty clay loam, 12 to 20 percent slopes
482E, 637E	Bellpine silty clay loam, 20 to 30 percent slopes
483F	Bellpine silty clay loam, 30 to 50 percent slopes
484D, 638D	Bellpine cobbly silty clay loam, 2 to 30 percent slopes*
461K	Blachly clay loam, 30 to 50 percent south slopes*
462H	Blachly clay loam, 50 to 70 percent south slopes*
464S	Blachly silty clay loam, 3 to 30 percent slopes*
466K	Blachly silty clay loam, 30 to 50 percent north slopes*
465K	Blachly silty clay loam, 30 to 50 percent south slopes*

Map Symbols	Mapping Unit Name
460S	Blachly-McCully complex, 3 to 30 percent slopes*
570S	Bohannon gravelly loam, 3 to 25 percent slopes*
571K	Bohannon gravelly loam, 25 to 50 percent slopes*
572H	Bohannon gravelly loam, 50 to 90 percent slopes*
20A	Brallier muck
21A	Brallier muck, tidal
140A	Brenner silty clay loam
141A	Brenner Variant silty clay loam
446B	Briedwell cobbly loam, 0 to 7 percent slopes
230B	Bullards-Ferrelo complex, 0 to 7 percent slopes
231C	Bullards-Ferrelo complex, 7 to 12 percent slopes
232D	Bullards-Ferrelo complex, 12 to 30 percent slopes
233F	Bullards-Ferrelo complex, 30 to 60 percent slopes
1A, 2A	Camas gravelly sandy loam, occasionally flooded
1AU	Camas-Urban land complex
31A	Chapman loam
31AU	Chapman-Urban land complex
30A	Chehalis silty clay loam, occasionally flooded
30AU	Chehalis-Urban land complex
500C, 500S	Chehulpum silt loam, 3 to 12 percent slopes
501E, 500S, 501F	Chehulpum silt loam, 12 to 40 percent slopes
4A	Cloquato silt loam
4AU	Cloquato-Urban land complex

Map Symbols	Mapping Unit Name
270A, 201A	Coburg silty clay loam
270AU	Coburg-Urban land complex
55A	Conser silty clay loam
310A	Courtney gravelly silty clay loam
630S	Cruiser gravelly clay loam, 3 to 25 percent slopes*
631K	Cruiser gravelly clay loam, 25 to 50 percent slopes*
632H	Cruiser gravelly clay loam, 50 to 70 percent slopes*
650S	Cumley silty clay loam, 2 to 20 percent slopes*
210C	Cupola cobbly loam, 3 to 12 percent slopes
211D	Cupola cobbly loam, 12 to 30 percent slopes
221A, 222A	Dayton silt loam, clay substratum
580S	Digger gravelly loam, 10 to 30 percent slopes*
581K	Digger gravelly loam, 30 to 50 percent slopes*
582H	Digger-Rock outcrop complex, 50 to 85 percent slopes*
408C	Dixonville silty clay loam, 3 to 12 percent slopes
406D	Dixonville silty clay loam, 12 to 30 percent slopes
409F	Dixonville silty clay loam, 30 to 50 percent slopes
374CU	Dixonville-Hazelair-Urban land complex, 3 to 12 percent slopes
375SU	Dixonville-Hazelair-Urban land complex, 12 to 35 percent slopes
374C	Dixonville-Philomath-Hazelair complex, 3 to 12 percent slopes
375S, 523C	Dixonville-Philomath-Hazelair complex, 12 to 35 percent slopes
72K	Dune land
477C	Dupee silt loam, 3 to 20 percent slopes*
380B	[1] Eilertsen silt loam

Map Symbols	Mapping Unit Name
565B	Fendall silt loam, 0 to 12 percent slopes
566D	Fendall silt loam, 12 to 25 percent slopes
76A	Fluvents, nearly level*
562S	1/ Formader loam, 3 to 30 percent slopes*
563K	Formader loam, 30 to 60 percent slopes*
165B	Haflinger-Jimbo complex, 0 to 5 percent slopes
520B	Hazelair silty clay loam, 2 to 7 percent slopes
521C	Hazelair silty clay loam, 7 to 20 percent slopes
520BU	Hazelair-Urban land complex, 2 to 7 percent slopes
204A	Heceta fine sand, 0 to 2 percent slopes
620S	Hembre-Klickitat complex, 3 to 30 percent slopes*
621K	Hembre-Klickitat complex, 30 to 60 percent slopes*
234A	Holcomb silty clay loam
625S	Holderman extremely cobbly loam, 5 to 25 percent slopes*
626K	Holderman extremely cobbly loam, 25 to 50 percent slopes*
627H	Holderman extremely cobbly loam, 50 to 75 percent slopes*
560S	Honeygrove silty clay loam, 3 to 25 percent slopes*
561K	Honeygrove silty clay loam, 25 to 50 percent slopes*
515S, 510B, 511C, 512D	Hullt loam, 2 to 30 percent slopes*
516K	Hullt loam, 30 to 60 percent slopes*
525S	Hummington gravelly loam, 5 to 25 percent slopes*
526K	Hummington gravelly loam, 25 to 50 percent slopes*
527H	Hummington gravelly loam, 50 to 75 percent slopes*

Map Symbols	Mapping Unit Name
385B	Jimbo silt loam, 0 to 3 percent slopes
166B	Jimbo-Haflinger complex, 0 to 5 percent slopes
550B	Jory silty clay loam, 2 to 12 percent slopes
551C	Jory silty clay loam, 12 to 20 percent slopes
552E	Jory silty clay loam, 20 to 30 percent slopes
640S	Keel cobbly clay loam, 3 to 25 percent slopes*
641K	Keel cobbly clay loam, 25 to 45 percent slopes*
642H	Keel cobbly clay loam, 45 to 75 percent slopes*
600K	Kilchis stony loam, 30 to 60 percent slopes*
601H	Kilchis stony loam, 60 to 90 percent slopes*
450S	Kinney cobbly loam, 2 to 20 percent slopes*
451KN	Kinney cobbly loam, 20 to 50 percent north slopes*
451K	Kinney cobbly loam, 20 to 50 percent south slopes*
452HN	Kinney cobbly loam, 50 to 70 percent north slopes*
452H	Kinney cobbly loam, 50 to 70 percent south slopes*
453S, 619S, 655S	Kinney cobbly loam, uneven, 3 to 30 percent slopes*
616S	Klickitat stony loam, 3 to 30 percent slopes*
617KN	Klickitat stony loam, 30 to 50 percent north slopes*
617K	Klickitat stony loam, 30 to 50 percent south slopes*
618HN	Klickitat stony loam, 50 to 75 percent north slopes*
618H	Klickitat stony loam, 50 to 75 percent south slopes*
351A	Linslaw loam
235B, 245B	Lint silt loam, 0 to 7 percent slopes

Map Symbols	Mapping Unit Name
236C	Lint silt loam, 7 to 12 percent slopes
237D	Lint silt loam, 12 to 20 percent slopes
238F	Lint silt loam, 20 to 40 percent slopes
260A	Malabon silty clay loam
260AU	Malabon-Urban land complex
470B	Marcola cobbly silty clay loam, 2 to 7 percent slopes
255C	Marty and Hembre soils, 3 to 12 percent slopes*
256D	Marty and Hembre soils, 12 to 25 percent slopes*
257K	Marty and Hembre soils, 25 to 60 percent slopes*
90A	McAlpin silty clay loam, 0 to 3 percent slopes
40A	McBee silty clay loam
461KN	McCully clay loam, 30 to 50 percent north slopes*
462HN	McCully clay loam, 50 to 70 percent north slopes*
670S	McDuff clay loam, 3 to 25 percent slopes*
671K	McDuff clay loam, 25 to 50 percent slopes*
672H	McDuff clay loam, 50 to 75 percent slopes*
395B	Meda loam, 2 to 12 percent slopes
690S, 620S	Minniece silty clay loam, 0 to 8 percent slopes
530S, 531S	Mulkey loam, 5 to 25 percent slopes
110A, 223A	Natroy silty clay loam
111A	Natroy silty clay
110AU	Natroy-Urban land complex
150A	Nehalem silt loam
420B, 425B	Nekia silty clay loam, 2 to 12 percent slopes

Map Symbols	Mapping Unit Name
421C, 426C	Nekia silty clay loam, 12 to 20 percent slopes
422E, 422D, 427E	Nekia silty clay loam, 20 to 30 percent slopes
423F	Nekia silty clay loam, 30 to 50 percent slopes
130A	1/ Nekoma silt loam
250D	Neskowin silt loam, 12 to 20 percent slopes
251F	Neskowin silt loam, 20 to 40 percent slopes
252K	Neskowin-Salander complex, 40 to 60 percent slopes
145A	Nestucca silt loam
240C	Netarts fine sand, 3 to 12 percent slopes
241D	Netarts fine sand, 12 to 30 percent slopes
10A	Newberg fine sandy loam
11A	Newberg loam
10AU, 11AU	Newberg-Urban land complex
350A	Noti loam
77K	Ochrepts and Umbrepts, very steep*
300A	Oxley gravelly silt loam
300AU	Oxley-Urban land complex
475C, 365B	Panther silty clay loam, 2 to 12 percent slopes
475CU	Panther-Urban land complex, 2 to 12 percent slopes
486S	Peavine silty clay loam, 3 to 30 percent slopes*
487K, 488H	Peavine silty clay loam, 30 to 60 percent slopes*
120A, 121A	Pengra silt loam, 1 to 4 percent slopes
120AU	Pengra-Urban land, 1 to 4 percent slopes

Map Symbols	Mapping Unit Name
416C, 416S	Philomath silty clay, 3 to 12 percent slopes
414C, 415C	Philomath cobbly silty clay, 3 to 12 percent slopes
415S, 417F	Philomath cobbly silty clay, 12 to 45 percent slopes*
415SU	Philomath-Urban land complex, 12 to 45 percent slopes*
575S	Preacher loam, 0 to 25 percent slopes*
576K	Preacher loam, 25 to 50 percent slopes*
577H	Preacher-Bohannon-Slickrock complex, 50 to 75 percent slopes*
469C	Ritner cobbly silty clay loam, 2 to 12 percent slopes*
474E, 470S 405C	Ritner cobbly silty clay loam, 12 to 30 percent slopes*
471K	Ritner cobbly silty clay loam, 30 to 60 percent slopes*
75A	Riverwash
700K	Rock outcrop-Kilchis complex, 30 to 90 percent slopes*
700KX	Rock outcrop-Witzel complex, 10 to 70 percent slopes*
590S	Salander silt loam, 12 to 30 percent slopes*
290A	Salem gravelly silt loam
290AU	Salem-Urban land complex
335B	Salkum silt loam, 2 to 6 percent slopes
330B	Salkum silty clay loam, 2 to 8 percent slopes
331C	Salkum silty clay loam, 8 to 16 percent slopes
445B	Saturn clay loam
322A, 320A	Sifton gravelly loam
585S	Slickrock gravelly loam, 3 to 25 percent slopes*
586K	Slickrock gravelly loam, 25 to 50 percent slopes*

Map Symbols	Mapping Unit Name
430B	Steiwer loam, 3 to 12 percent slopes
431C	Steiwer loam, 12 to 20 percent slopes
432E	Steiwer loam, 20 to 50 percent slopes
567S	Tahkenitch loam, 3 to 20 percent slopes*
568K	Tahkenitch loam, 20 to 45 percent slopes*
569H	Tahkenitch loam, 45 to 75 percent slopes*
540S	Tolovano silt loam,3 to 30 percent slopes*
541K	Tolovano silt loam, 30 to 60 percent slopes*
543H	Tolovano-Hembre-Klickitat complex 50 to 80 percent slopes*
360B	Veneta loam, 0 to 7 percent slopes
361B	Veneta Variant silt loam, 0 to 7 percent slopes
100A	Waldo silty clay loam
50A, 51A	Wapato silty clay loam
205C, 72KS	Westport fine sand, 0 to 12 percent slopes
206D	Westport fine sand, 12 to 30 percent slopes*
207H	Westport fine sand, 30 to 70 percent slopes*
205CU	Westport-Urban land complex, 0 to 12 percent slopes
490B	Willakenzie clay loam, 2 to 12 percent slopes
491C	Willakenzie clay loam, 12 to 20 percent slopes
492D	Willakenzie clay loam, 20 to 30 percent slopes
493F	Willakenzie clay loam, 30 to 50 percent slopes
135A	Willanch fine sandy loam
701K, 702H	Winberry very gravelly loam, 10 to 45 percent slopes*

Map Symbols	Mapping Unit Name
440S	Witzel very cobbly loam, 3 to 30 percent slopes*
441K	Witzel very cobbly loam, 30 to 75 percent slopes*
203A	Woodburn silt loam, 0 to 3 percent slopes
225A	Yaquina loamy fine sand
225AU	Yaquina-Urban land complex
706K	Yellowstone-Rock outcrop complex, 10 to 60 percent slopes*

* Broadly defined units
1/ Proposed series - name not reserved

Summary of Changes Made in the
Identification Legend Dated June 22, 1978
Lane County, Oregon

The following map units have been added to the legend:

246S	Astoria silt loam, 5 to 30 percent slopes*
562S	Formader loam, 3 to 30 percent slopes*
563K	Formader loam, 30 to 60 percent slopes*
620S	Hembre-Klickitat complex, 3 to 30 percent slopes*
621K	Hembre-Klickitat complex, 30 to 60 percent slopes*
252K	Neskowin-Salander complex, 40 to 60 percent slopes*
590S	Salander silt loam, 12 to 30 percent slopes*
540S	Tolovano silt loam, 3 to 30 percent slopes*
541K	Tolovano silt loam, 30 to 60 percent slopes*
543H	Tolovano-Hembre-Klickitat complex, 50 to 80 percent slopes*

The following changes in map unit names have been approved:

	From	To
216D	Bandon sandy loam, 12 to 30 percent slopes	Bandon sandy loam, 12 to 50 percent slopes
217H	Bandon sandy loam, 30 to 70 percent slopes	Bandon sandy loam, 12 to 50 percent slopes
460S	Blachly-McCully association, 3 to 30 percent slopes*	Blachly-McCully complex, 3 to 30 percent slopes*
72KS	Dune land, stabilized	Westport fine sand, 0 to 12 percent slopes
625S	Holderman very gravelly loam, 5 to 25 percent slopes*	Holderman extremely cobbly loam, 5 to 25 percent slopes*

	From	To
626K	Holderman very gravelly loam, 25 to 50 percent slopes*	Holderman extremely cobbly loam, 25 to 50 percent slopes*
627H	Holderman very gravelly loam, 50 to 75 percent slopes*	Holderman extremely cobbly loam, 50 to 75 percent slopes
515S	Hullt clay loam, 2 to 30 percent slopes*	Hullt loam, 2 to 30 percent slopes*
516K	Hullt clay loam, 30 to 60 percent slopes*	Hullt loam, 30 to 60 percent slopes*
245B	Lint complex, 0 to 7 percent slopes	Lint silt loam, 0 to 7 percent slopes
531S	Mulkey-Rock outcrop complex, 5 to 25 percent slopes	Mulkey loam, 5 to 25 percent slopes
130A	Nehalem Variant silt loam	Nekoma silt loam
700K	Rock outcrop-Kilchis complex, 30 to 60 percent slopes*	Rock outcrop-Kilchis complex, 30 to 90 percent slopes*
445B	Saturn silt loam	Saturn clay loam
361B	Veneta Variant loam	Veneta Variant silt loam
702H	Winberry very gravelly loam, 45 to 70 percent slopes	Winberry very gravelly loam, 10 to 45 percent slopes

The following map units have been deleted from the legend:

253B Neskowin Variant silt loam, 3 to 12 percent slopes

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* Broadly defined units

Classification of the Soils of
Lane County Area, Oregon
June, 1979

Abiqua	Fine, mixed, mesic Cumulic Ultic Haploxerolls
Astoria	Medial, mesic Andic Haplumbrepts
Atring	Loamy-skeletal, mixed, mesic Dystric Xerochrepts
Awbrig	Fine, montmorillonitic, mesic Vertic Albaqualfs
Bandon	Coarse-loamy, mixed, mesic, ortstein Typic Haplorthods
Bashaw	Very-fine, montmorillonitic, mesic Typic Pelloxererts
Bellpine	Clayey, mixed, mesic Xeric Haplohumults
Blachly	Fine, mixed, mesic Umbric Dystrochrepts
Bohannon	Fine-loamy, mixed, mesic Typic Haplumbrepts
Brallier	Dysic, mesic Typic Medihemists
Brenner	Fine, mixed, acid, mesic Fluvaquentic Humaquepts
Briedwell	Loamy-skeletal, mixed, mesic Ultic Haploxerolls
Bullards	Coarse-loamy, mixed, mesic Typic Haplorthods
Camas	Sandy-skeletal, mixed, mesic Fluventic Haploxerolls
Chapman	Fine-loamy, mixed, mesic Cumulic Ultic Haploxerolls
Chehalis	Fine-silty, mixed, mesic Cumulic Ultic Haploxerolls
Chehulpum	Loamy, mixed, mesic, shallow Ultic Haploxerolls
Cloquato	Coarse-silty, mixed, mesic Cumulic Ultic Haploxerolls
Coburg	Fine, mixed, mesic Pachic Ultic Argixerolls
Conser	Fine, mixed,mesic Typic Argiaquolls
Courtney	Fine, montmorillonitic, mesic Abruptic Argiaquolls
Cruiser	Medial Andic Cryochrepts

Cumley	Clayey, mixed, mesic Typic Haplohumults
Cupola	Loamy-skeletal, mixed, mesic Typic Dystrochrepts
Dayton	Fine, montmorillonitic, mesic Typic Albaqualfs
Digger	Loamy-skeletal, mixed, mesic Andic Dystric Eutrochrepts
Dixonville	Fine, mixed, mesic Pachic Ultic Argixerolls
Dupee	Fine, mixed, mesic Aquultic Haploxeralfs
Eilertsen	Fine-silty (fine-loamy) mixed, mesic Ultic Haploxeralfs
Fendall	Fine, mixed, mesic Typic Haplumbrepts
Ferrelo	Coarse-loamy, mixed, mesic Typic Haplumbrepts
Formader	Medial, mesic Andic Haplumbrepts
Haflinger	Sandy-skeletal, mixed, mesic Entic Haplumbrepts
Hazelair	Very-fine, mixed, mesic Aquultic Haploxerolls
Heceta	Mixed, mesic Typic Psammaquents
Hembre	Fine-loamy, mixed, mesic Typic Haplumbrepts
Holcomb	Fine, montmorillonitic, mesic Mollic Albaqualfs
Holderman	Loamy-skeletal, mixed Andic Cryochrepts
Honeygrove	Clayey, mixed, mesic Typic Haplohumults
Hullt	Fine-loamy, mixed, mesic Typic Xerumbrepts
Hummington	Loamy-skeletal, mixed Typic Cryumbrepts
Jimbo	Medial, mesic Andic Haplumbrepts
Jory	Clayey, mixed, mesic Xeric Haplohumults
Keel	Medial Andic Cryumbrepts
Kilchis	Loamy-skeletal, mixed, mesic Lithic Haplumbrepts
Kinney	Medial, mesic Andic Haplumbrepts
Klickitat	Loamy-skeletal, mixed, mesic Typic Haplumbrepts
Linslaw	Fine, mixed, mesic Aquultic Haploxeralfs

Lint	Medial, mesic Typic Dystrandepts
Malabon	Fine, mixed, mesic Pachic Ultic Argixerolls
Marcola	Clayey-skeletal, mixed, mesic Pachic Ultic Argixerolls
Marty	Medial, mesic Andic Haplumbrepts
McAlpin	Fine, mixed, mesic Cumulic Ultic Haploxerolls
McBee	Fine-silty, mixed, mesic Cumulic Ultic Haploxerolls
McCully	Fine, mixed, mesic Typic Haplumbrepts
McDuff	Clayey, mixed,mesic Typic Haplohumults
Meda	Fine-loamy, mixed, mesic Typic Haplumbrepts
Minniece	Fine, mixed, mesic Typic Umbraqualfs
Mulkey	Medial Dystric Cryandepts
Natroy	Very-fine, montmorillonitic, mesic Aquic Chromoxererts
Nehalem	Fine-silty, mixed, mesic Fluventic Haplumbrepts
Nekia	Clayey, montmorillonitic, mesic Xeric Haplohumults
Nekoma	Coarse-loamy, mixed, mesic Fluventic Haplumbrepts
Neskowin	Medial, mesic Typic Dystrandepts
Nestucca	Fine-silty, mixed, acid, mesic Fluvaquentic Humaquepts
Netarts	Sandy, mixed, mesic Entic Haplorthods
Newberg	Coarse-loamy, mixed, mesic Fluventic Haploxerolls
Noti	Coarse-loamy over sandy or sandy-skeletal, mixed, acid, mesic Typic Humaquepts
Oxley	Loamy-skeletal, mixed, mesic Typic Argixerolls
Panther	Very-fine, montmorillonitic, mesic, Typic Haplaquolls
Peavine	Clayey, mixed, mesic Typic Haplohumults
Pengra	Fine-silty over clayey, montmorillonitic, mesic Typic Haplaquolls

Philomath	Clayey, montmorillonitic, mesic, shallow Vertic Haploxerolls
Preacher	Fine-loamy, mixed, mesic Typic Haplumbrepts
Ritner	Clayey-skeletal, mixed, mesic Dystric Xerochrepts
Salander	Medial, mesic Typic Dystrandepts
Salem	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Pachic Ultic Argixerolls
Salkum	Clayey, kaolinitic, mesic Xeric Haplohumults
Saturn	Fine-loamy over fragmental, mixed, mesic Fluventic Haplumbrepts
Sifton	Medial over sandy or sandy-skeletal, mixed,mesic Umbric Vitrandepts
Slickrock	Fine-loamy, mixed, mesic Pachic Haplumbrepts
Steiwer	Fine-loamy, mixed, mesic Ultic Haploxerolls
Tahkenitch	Coarse-loamy, mixed, mesic Typic Haplumbrepts
Tolovano	Medial, mesic Andic Haplumbrepts
Veneta	Fine, mixed, mesic Ultic Haploxeralfs
Veneta Variant	Fine-loamy, mixed, mesic Ultic Haploxeralfs
Waldo	Fine, mixed, mesic Fluvaquentic Haplaquolls
Wapato	Fine-silty, mixed,mesic Fluvaquentic Haplaquolls
Wesport	Mixed, mesic Typic Udipsamments
Willakenzie	Fine-silty, mixed, mesic Ultic Haploxeralfs
Willanch	Coarse-loamy, mixed, non-acid, mesic Fluvaquentic Humaquepts
Winberry	Loamy-skeletal, mixed Lithic Cryochrepts
Witzel	Loamy-skeletal, mixed, mesic Lithic Ultic Haploxerolls
Woodburn	Fine-silty, mixed, mesic Aquultic Argixerolls
Yaquina	Sandy, mixed, mesic Aquic Haplorthods
Yellowstone	Loamy-skeletal, mixed Lithic Cryumbrepts

C. Genetic Key to the Soil Series of the Eugene District

I. Moisture Regimes

A. Xeric: Below permanent wilting point 60 consecutive days in seven out of ten years.

B. Udic: Below permanent wilting point less than 60 consecutive days and/or in less than seven out of ten years.

II. Temperature Regimes

A. Mesic: Mean annual soil temperature is more than 47°F.

B. Cryic: Mean annual soil temperature is less than 47°F.

III. Vegetation

Zones	Xeric/Mesic	Udic/Mesic	Udic/Cryic
	Douglas-fir Oregon white oak*	Douglas-fir Western redcedar	Douglas-fir Western redcedar
Dominant or Indicative Vegetation	Poison oak	Grand fir	Western hemlock
	Madrone*	Vine maple	Silver fir*
	Incense-cedar	Red alder	Western white pine*
	Ocean spray*	Red huckleberry*	Blue huckleberry
	Hazel Chinquapin Manzanita Salal	Sword fern* Salmonberry Thimbleberry Maidenhair fern Bigleaf maple Oxalis	Beargrass*

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* Most significant indicator species

IV. Xeric/Mesic Soils

A. Atring - Typic Xerochrept, Loamy-skeletal over fragmental, mixed, moderately deep.

Dupee - Aquultic Haploxeralfs, Fine, mixed, deep.

Willakenzie - Ultic Haploxeralfs, Fine-silty, mixed, moderately deep.

B. Xeric/Mesic Soils Over Basic Igneous Rocks

Dixonville - Pachic Ultic Argixerolls, Fine, mixed, moderately deep.

Nekia - Xeric Haplohumults, Clayey, mixed, moderately deep.

Philomath - Vertic Haploxerolls, Clayey, montmorillonitic, Shallow.

Ritner - Dystric Xerochrepts, Clayey-skeletal, mixed, deep.

C. Xeric/Mesic Soils Occurring Over Pyroclastic Rocks (Tuffs and Breccias)

Hazelair - Aquultic Haploxerolls, very fine, mixed, moderately deep.

D. Xeric/Mesic Soils Occurring Over Both Sedimentary Rocks and Pyroclastics (Tuffs and Breccias)

Bellpine - Xeric Haplohumults, Clayey, mixed, moderately deep.

E. Xeric/Mesic Soils Occurring Over Basic Igneous, Sedimentary, and Pyroclastic Rocks

Jory - Xeric Haplohumults, Clayey, mixed, deep.

F. Xeric/Mesic Soils from Alluvium

Abiqa - Cumulic Ultic Haploxerolls, Fine, mixed, deep.

Cloquato - Cumulic Ultic Haploxerolls, Coarse-silty, mixed deep.

McAlpin - Cumulic Ultic Haploxerolls, Fine, mixed, deep.

Veneta - Ultic Haploxeralfs, Fine, mixed, deep.

V. Udic/Mesic Soils

A. Udic/Mesic Soils Over Sedimentary Rocks

Apt - Typic Haplohumults, Clayey, mixed, deep.

Blachly - Umbric Dystrochrepts, Fine, mixed, deep.

Digger - Dystric Eutrochrepts, Loamy-skeletal, mixed, moderately deep.

Harrington - Typic Haplumbrepts, Loamy-skeletal, mixed, moderately deep.

Jason - Dystric Eutrochrepts, Loamy-skeletal, mixed, shallow.

Preacher - Typic Haplumbrepts, Fine-loamy, mixed, deep.

Slickrock - Pachic Haplumbrepts, Fine-loamy, mixed, deep.

Umpcoos - Lithic Dystrochrepts, Loamy-skeletal, mixed.

Unnamed 166 - Dystric Eutrochrepts, Loamy-skeletal, mixed, moderately deep.

B. Udic/Mesic Soils Over Basic Igneous Rocks

Cumley - Typic Haplohumults, Clayey, mixed, deep.

Hembre - Typic Haplohumults, Fine-loamy, mixed, deep.

Kilchis - Lithic Haplumbrepts, Loamy-skeletal, mixed.

Klickitat - Typic Haplumbrepts, Loamy-skeletal, mixed, deep.

Marty - Andic Dystrochrepts, Medial, deep.

McCully - Typic Haplumbrepts, Fine, mixed, deep.

Minniece - Typic Umbraqualfs, Fine, mixed, deep.

Panther - Typic Haplaquolls, Very fine, montmorillonitic, deep.

C. Udic/Mesic Soils Over Basic Igneous and Sedimentary Rocks

Bohannon - Typic Haplumbrepts, Fine-loamy, mixed, moderately deep.

D. Udic/Mesic Soils Over Basic Igneous Rocks and Pyroclastics (Tuffs and Breccias)

Kinney - Andic Haplumbrepts, Medial, deep.

E. Udic/Mesic Soils Over Basic Igneous Rocks and Pyroclastics (Tuffs and Breccias)

Honeygrove - Typic Haplohumults, Clayey, mixed, deep.

Peavine - Typic Haploumults, Clayey, mixed, moderately deep.

F. Udic/Mesic Soils From Alluvium

Jimbo - Andic Haplumbrepts, Medial, deep.

Meda - Typic Haplumbrepts, Fine-loamy, mixed, moderately deep.

Nehalem - Fluventic Haplumbrepts, Fine-silty, mixed, deep.

Nestucca - Fluvaquentic Humaquepts, Fine-silty, mixed, acid, deep.

Saturn - Fluventic Haplumbrepts, Fine-loamy over fragmental, mixed, deep.

Sifton - Umbric Vitrandepts, Medial over sandy or sandy-skeletal, mixed, deep.

VI. Udic/Cryic Soils

A. Udic/Cryic Soils Over Basic Igneous Rocks

Cruiser - Andic Cryochrepts, Medial, deep.

Holderman - Dystric Cryochrept, Loamy-skeletal, mixed, moderately deep.

Hummington - Typic Cryumbrepts, loamy-skeletal, mixed, moderately deep.

Keel - Andic Cryumbrepts, Medial, deep.

Mulkey - Dystric Cryandepts, Medial, moderately deep.

Winberry - Lithic Cryochrepts, Loamy-skeletal, mixed.

Yellowstone - Lithic Cryumbrepts, Loamy-skeletal, mixed.

D. Soil Taxonomy

(This section to be added at a later date).

Table 1. GENETIC KEY TO THE SOIL SERIES

SOIL SERIES	UNDERLYING BEDROCK	PROFILE DEPTH (in)	FAMILY TEXTURAL GROUPING	COLOR (MOIST) SUBSOIL	KIND OF SUBSOIL HORIZON	KIND OF SURFACE HORIZON	REMARKS
I. SOILS OF THE XERIC SOIL MOISTURE REGIME AND MESIC SOIL TEMPERATURE REGIME							
Abiqua	Alluvium	40-60+	Fine	Dark Reddish Brown	Cambic	Mollic	Mixed Alluvial Land
Atring	Sedimentary	20-40	Loamy-skeletal	Brown	Cambic	Ochric	
Bellpine	Sedimentary/ Pyroclastic	20-40	Clayey	Reddish Brown	Argillic	Umbric	
Cloquato	Alluvium	40-60+	Coarse-Silty	Dark Brown		Mollic (Cumulic)	Mixed Alluvial Land
Dixonville	Basic Igneous	20-40	Fine	Dark Reddish Brown	Argillic	Mollic (Pachic)	
Dupee	Sedimentary	40-60+	Fine	Dark Yellowish Brown	Argillic	Ochric	Aquic Moisture Regime
Hazelair	Pyroclastics	20-40	Very Fine	Dark Brown	Cambic	Mollic	Aquic Moisture Regime
Jory	Basalt, Sed., Pyroclastics	40-60+	Clayey	Dark Reddish Brown	Argillic	Umbric	
McAlpin	Alluvium	40-60+	Fine	Dark Reddish Brown	Cambic	Mollic (Cumulic)	
Nekia	Basic igneous	20-40	Clayey	Dark Reddish Brown	Argillic	Umbric	
Philomath	Basic igneous	15-20	Clayey	Very Dark Brown		Mollic	Paralithic Contact
Ritner	Basic igneous	40-60+	Clayey-skeletal	Dark Reddish Brown	Cambic	Ochric	
Veneta	Alluvium	40-60+	Fine	Dark Yellowish Brown	Argillic	Ochric	
Willakenzie	Sedimentary	20-40	Fine-silty	Dark Brown	Argillic	Ochric	
Witzel	Basic igneous	12-20	Loamy-skeletal	Dark Brown	Cambic	Mollic	
II. SOILS OF THE UDIC SOIL MOISTURE REGIME AND MESIC SOIL TEMPERATURE REGIME							
Honeygrove	Sedimentary or Volcanic	40-60	Clayey	Dark Red	Argillic	Umbric	
Peavine	Sedimentary or Volcanic	20-40	Clayey	Reddish Brown	Agrillic	Umbric	
Hembre	Gabbro or diorite	40-60+	Fine-loamy	Reddish Brown	Cambic	Umbric	
Harrington	Gabbro or diorite	20-40	Loamyskeletal	Reddish Brown	Cambic	Umbric	
Kilchis	Gabbro or diorite	10-20	Loamy-skeletal	Reddish Brown	Cambic	Umbric	
Apt	Sedimentary	40-60+	Clayey	Dark Brown	Argillic	Umbric	
Slickrock	Sedimentary	40-60+	Fine-loamy	Dark Brown	Cambic	Pachic	
Preacher	Sedimentary	40-60+	Fine-loamy	Dark Yellowish Brown	Cambic	Umbric	
Bohannon	Sedimentary	20-40	Fine-loamy	Dark Brown	Cambic	Umbric	
Jason	Sedimentary	10-20	Loamy-skeletal	Brown	Cambic	Ochric	Paralithic Contact
Digger	Sedimentary	20-40	Loamy-skeletal	Dark Brown	Cambic	Ochric	

GENETIC KEY TO THE SOIL SERIES (Continued)

SOIL SERIES	UNDERLYING BEDROCK	PROFILE DEPTH (in)	FAMILY TEXTURAL GROUPING	COLOR (MOIST) SUBSOIL	KIND OF SUBSOIL HORIZON	KIND OF SURFACE HORIZON	REMARKS
McCully	Sedimentary or Volcanic	40-60+	Fine	Dark Reddish Brown	Cambic	Umbric	
Unnamed	Sedimentary	40-60+	Loamy-skeletal	Dark Brown	Cambic	Ochric	
Umpcoos	Sedimentary	10-20	Loamy-skeletal	Brown	Cambic	Ochric	Lithic Contact
Blachly	Sedimentary	40-60+	Fine	Yellowish Red	Cambic	Ochric	
Cumley	Basic Igneous	40-60+	Clayey	Dark Brown	Argillic	Umbric	
Klickitat	Basic Igneous	40-60+	Loamy-skeletal	Dark Reddish Brown	Cambic	Ochric	
Marty	Basic Igneous	40-60+	Medial	Reddish Brown	Cambic	Ochric	
Minniece	Basic Igneous	40-60+	Fine	Dark Grayish Brown	Argillic	Ochric	Aquic Moisture Regime
Panther	Basic Igneous	40-60+	Very Fine	Olive Brown	Cambic	Mollisols	Aquic Moisture Regime
Kinney	Basalt/Pyroclastics	40-60+	Medial	Dark Brown	Cambic	Ochric	
Jimbo	Alluvium	40-60+	Medial	Dark Yellowish Brown	Cambic	Ochric	
Meda	Alluvium	20-40	Fine-loamy	Dark Yellowish Brown	Cambic	Ochric	
Nehalem	Alluvium	40-60+	Fine-silty	Dark Brown	Cambic	Ochric	
Neatucca	Alluvium	40-60+	Fine-silty	Dark Grayish Brown	Cambic	Ochric	Aquic Moisture Regime
Saturn	Alluvium	40-60+	Fine-loamy/ Fragmental	Dark Brown	Cambic	Ochric	
Sifton	Alluvium	40-60+	Medial/ Sandy-skeletal	Dark Brown		Ochric	
III. SOILS OF THE UDIC MOISTURE REGIME AND CRYIC SOIL TEMPERATURE REGIME							
Cruiser	Basic Igneous	40-60+	Medial	Reddish Brown	Cambic	Ochric	
Holderman	Basic Igneous	20-40	Loamy-skeletal	Brown	Cambic	Ochric	
Keel	Basic Igneous	40-60+	Medial	Brown	Cambic	Ochric	
Mulkey	Basic Igneous	20-40	Medial	Dark Brown	Cambic	Ochric	
Winberry	Basic Igneous	10-20	Loamy-skeletal	Brown	Cambic	Ochric	
Yellowstone	Basic Igneous	10-20	Loamy-skeletal	Dark Brown		Ochric	

Table 2. The relation between median soil permeability, rainfall, for 6 hour storms at 25 to 50 year frequencies, and expected runoff from these storms for selected undisturbed soils extensively found in Oregon's Coastal mountains. 1/

Soil Series	Median Permeability Rate	Median Percolation in 6 hours	6-hour precipitation once in: 2/ 25 years	50 years	Expected runoff from 6-hour storm once in: 25 years	50 years
Xeric Soils	in/hr	in	in	in	in	in
Witzel	0.42	2.52	2.2	2.4	0.0	0.0
Bellpine	0.17	1.02	2.2	2.4	1.18	1.38
Jory	0.42	2.52	2.2	2.4	0.0	0.0
Udic Soils						
Umpcoos	4.2	25.2	3.0	3.2	0.0	0.0
Bohannon	4.2	25.2	3.0	3.2	0.0	0.0
Preacher	1.3	7.8	3.0	3.2	0.0	0.0
Honeygrove	0.42	2.52	3.0	3.6	0.48	0.68
Kilchis	4.2	25.2	3.4	3.6	0.0	0.0
Klickitat	1.3	7.8	3.4	3.6	0.0	0.0
McCully	0.42	2.52	3.4	3.6	0.88	1.08

1/ Chalfant, G. R., Thomas, B. R., Pomerening J. A., and Norgren, J. A., Soil Inventory of the Siuslaw River Master Unit West of the Willamette Valley - Coast Range Divide, Eugene District Bureau of Land Management. (unpublished Soil Inventory).

2/ The rainall data are from isopluvial maps for the U. S. Department of Agriculture, Soil Conservation Service, by the U. S. Department of Commerce, National Weather Service. March, 1971.

Table 3. Productivity Potential of the Most Common Soils by Resource Area

Productive Potential of the Most Common Soils in the Noti and Lorane Resource Areas is to be added at a later date.

* Table 4. Regeneration, Burning, and Compaction Hazards is to be added at a later date.

* Table 5. Engineering Properties and Limitation Ratings is to be added at a later date.